III. WATER POLLUTION CONTROL REGULATION CASE STUDY

This case study illustrates a methodology for conducting and a means of reporting on the economic analysis portion of a Regulatory impact Analysis (RIA) for a hypothetical water pollution control standard. The study is intended to be illustrative and thus serve as a guidance document for the carrying out of similar (though actual) studies of regulatory impacts. The report is similar in format to the preceding Air Pollution Control Regulation Case Study; moreover, as with the first case study, the data used in this analysis are merely illustrative. To reduce the complexity of this hypothetical case study, Pollutants X, Y and Z are assumed to exist at harmful levels in but two regions; however, the aggregation problems often encountered in determining national level benefits and costs are illustrated for these regions. "Adding up" the total benefits and costs of these two regions is analogous to adding up regional-level. benefits and costs to estimate national totals. These regions reflect the regionally differing major concerns relevant to preparing an RIA (e.g., pollutant levels, population, and industry characterizations).

As with the first case study, this analysis assumes that a discussion of the need for the regulatory action and the relevant statutory authority have been presented elsewhere (an abbreviated "Background" section is included). The format and depth of analyses of the elements of the RIA are only illustrative--the Agency is not as yet committed to any specific format, and the depth of analysis must clearly be tailored to the problem at hand.

The case study is organized into seven major sections. The first, the Net Benefits Evaluation and Impact Summary, summarizes the findings and outlines the types of analyses necessary to complete an RIA. The second section, Background, outlines information pertinent to the two regions examined. The remaining five sections--Social Benefits, Social Costs, Economic Impacts, Net Benefits Timestreams and Sensitivity Analysis, and Cost Effectiveness--present the analyses used in this case study and illustrate the procedures which are necessary for completing an RIA.

A. Net Benefits Evaluation and Impact Summary

Tables 25 through 30 summarize the information contained in the RIA's Executive Summary. Though results are provided for only one of the regulatory alternatives, in actual case studies such development would be needed for each alternative that is among the least-cost set of alternatives as determined from appropriate cost-effectiveness analysis (see Section G). For the alternative shown, Tables 25-30 present information for each of the three major analyses--benefits, costs, and economic impacts--and show the alternative's quantitative and nonquantitative effects. Monetized impacts cover a twenty-year planning period (beginning in 1982), and all values are expressed in 1982 dollars.

Table 25, Part A, shows the present values for the quantified net social benefits of the proposed Industry Q water pollution control regulation using alternate discount rates. For example, the present value of the total social benefits minus the total social costs over the 20-year period of analysis is $88.6 million at the 10 percent discount rate. For lower discount rates, e.g., 6 and 8 percent, the present values of the net social benefits are higher, and for higher discount rates, e.g., 12 percent, the present values are lower. (The present value of the net social benefits would be zero at a discount rate of approximately 17 percent for this case study.) Other sensitivity analysis results varying benefits and cost values are shown in Section F.

Table 25, Part B, summarizes the unquantified benefits and costs associated with the proposed regulation. It appears that the unquantified benefits will exceed the unquantified costs based upon qualitative judgments. Furthermore, an estimated 13 cancer deaths (a quantifiable but nonmonetizable impact) will be avoided with the regulation--a further benefit excluded from the present value calculations. Had costs exceeded benefits in the present value calculations, then the excess cost per death avoided would be a measure that would be reported--of course, if data permits health impacts to be stated in probabilistic terms, this should be done:

Annual, undiscounted benefits and costs are presented in Table 26 to show benefit accrual and cost expenditures over the 20-year planning period. Net social benefits (the differences between benefits and costs) were calculated on an annual basis and, as shown, they are negative from Year 1 through Year 3. Beyond this period, net social benefits are positive and increase to $44.8 million in the 20th year.

Table 27 summarizes the social benefits of the proposed regulation by benefit type. The monetizable benefits are shown by year over the planning period, including ranges in the benefit values, to reflect uncertainties regarding available data and the implementable analytic procedures for estimating specific types of benefits. The five major types of benefits shown include health, recreation, aesthetic-existence, diversionary use, and ecological benefits. The aesthetic-existence and instream recreational benefits are the highest: the former ranges from $19.8 million in the first year of the planning period to $72.7 million in the last; the latter ranges from $5.6 million in the first year to $30.2 million in the last. The quantifiable health and ecological benefits are the lowest, and in the twentieth year reach highs of only $.132 and $1.2 million, respectively. Table 27 also presents the major quantifiable/nonmonetizable health

Table 25. Net social benefits from the proposed Industry Q water pollution control regulation using alternate discount rates

Part A. Quantified Benefits and Costs

	Present value 1/ using alternate discount rates			
	6%	8 %	10%	12%
	------------millions of dollars------------			
Social Benefits	958.7	802.2	679.8	583.1
Social Costs	775.6	672.8	591.2	525.6
Net Social Benefits 2/	183.1	129.4	88.6	57.5

Part B. Unquantified Benefits and Costs

The unquantified benefits include:

- reduced pain and suffering
- reduced threat of illness and death
- decreased levels of liver and kidney disfunction

The unquantified costs include:

- negative secondary employment effects in communities with plant closures
- positive employment effects in the construction industry (to install the equipment) and in Industry Q itself (to operate and maintain pollution control equipment).

1/ Present values of costs and benefits over a 20-year planning period in 1982 constant dollars.

2/ Approximately 13 premature deaths would be avoided with the proposed regulation during the 20-year planning period.

Table 26. Undiscounted total social benefits, total social costs and net social benefits for the proposed Industry Q water pollution control regulation by year

	Year	Total social benefits 1/		Total social costs 2/		Net social benefits 3/	
		Estimate	Range	Estimate	Range	Estimate	Range
		----------millions of dollars----------					
1	1982	26.2	18.5- 32.1	80.9	73.3-88.6	(54.7) 4/	(54.8)-(56.5)
2	1983	51.5	37.1- 65.3	96.9	87.8-106.1	(45.4)	(50.7)-(40.8)
3	1984	77.7	56.9- 98.8	113.8	102.9-124.6	(36.1)	(46.0)-(25.8)
4	1985	78.6	57.4- 99.9	56.3	51.0- 61.6	22.3	6.4 - 38.3
5	1986	79.4	58.1-101.0	56.2	50.9- 60.5	23.2	7.2 - 40.5
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10	1991	95.4	70.2-120.9	58.0	52.5- 63.5	39.4	17.7 - 57.4
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.							
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15	1996	100.6	74.0-127.8	61.8	55.9- 67.7	38.8	18.1 - 60.1
.							
.							
20	2001	106.5	78.3-134.8	61.7	55.8- 67.6	44.8	22.5 - 67.2

1/ In 1982 constant dollars (using a forecast of the GNP Implicit Price Deflator).
2/ In 1982 constant dollars.
3/ Total social benefits minus total social costs.
4/ Numbers in parenthesis are negative.

Table 27. Summary of total social benefits for the proposed Industry Q water pollution control regulation by year

Part A. Quantifiable/Monetizable Benefits 1/

		Benefit types											
		Health		Instream recreational		Aesthetic/Existence		Diversionary use		Ecological		Total benefits 2/	
	Year	Estimate	Range	Estimate	Range	Estimate	Range	Estimate	Range	Estimate	Range	Estimate	Range
		millions of dollars											
1	1982	.004	<.001	5.6	3.3- 6.1	19.8	14.5-25.0	.6	.57-.7	.2	.1- .3	26.2	18.5- 32.1
2	1983	.008	.007-.009	9.6	6.7-12.4	40.0	29.4-50.7	1.3	1.2 -1.4	.6	.4- .8	51.5	37.7- 65.3
3	1984	.012	.010-.014	14.3	10.1-18.7	60.6	44.5-76.8	2.0	1.8 -2.1	.8	.5-1.2	77.7	56.9- 98.8
4	1985	.018	.015-.019	17.6	10.2-19.0	61.2	44.9-77.6	2.0	1.8 -2.1	.8	.5-1.2	78.6	57.4- 99.9
5	1986	.021	.019-.024	14.7	10.3-19.2	61.9	45.4-78.4	2.0	1.8 -2.2	.8	.6-1.2	79.4	58.1-101.0
.													
.													
10	1991	.044	.039-.048	27.1	19.8-34.5	65.3	47.9-82.7	2.1	1.9 -2.3	.9	.6-1.3	95.4	70.2-120.9
15	1996	.078	.070-.086	28.3	20.8-36.4	60.9	50.5-87.2	2.2	1.9 -2.5	1.1	.7-1.6	100.6	74.0-177.8
.													
.													
20	2001	.132	.119-.146	30.2	22.0-38.4	72.7	53.4-92.0	2.3	2.1 -2.6	1.2	.7-1.6	106.5	78.3-134.8

Part B. Quantifiable/Nonmonetitable Benefits

During the twenty-year planning period, an estimated 13 cancer incidents (and by definition deaths) will be avoided due to the proposed regulatory alternative.

Part C. Nonquantifiable Benefits

1. Reduced pain and suffering
2. Reduced threat of illness and death
3. Decreased levels of liver and kidney disfunction

1/ In 1982 constant dollars (using the GNP Implicit Price Deflator) to allow direct comparison with costs. Additionally, the beginning of the examined planning period is 1982 and present values were calculated for that year.

2/ The sum of the individual costs may not equal the total costs due to rounding errors.

benefits (Part B) and a listing of nonquantifiable benefits (Part C). These latter benefits are particularly important when the present value of net social benefits is relatively minor or negative. The quantifiable/ nonmonetizable benefits include the avoidance of 13 cancer incidents. Non-quantifiable benefits include reduced pain and suffering, reduced threat of illness and death, and decreased levels of liver and kidney disfunction.

Table 28 summarizes total social costs by type of cost, including private sector real resource costs, deadweight welfare loss, government regulatory costs, and adjustment costs. Private sector real resource costs are the highest and range from a low of $55.0 million in the fourth year to a high of $112.2 million in the third year. Adjustment costs are next highest with a high of $0.7 million in the third year and a low (excluding year one) of $0.5 million in the 20th year. Government administrative costs range from about $.7 million in the third year to $.1 million in the 20th. Deadweight welfare costs remain at approximately $0.1 million per year.

The preceding benefits and costs reflect the major efficiency-related impacts of the proposed regulation. Equity-related impacts are also of concern in an RIA. Table 29 summarizes the major economic impacts that are. projected to result from the regulation with the implicit focus on equity issues. Six categories of effects included in the table are the following: financial, price, production, employment, community, and "other" effects. In some cases, the economic impacts associated with a proposed regulation may result in modifying implementation strategies or developing transitional programs to compensate for major inequities caused by regulations.

Table 29 indicates that all four model plant sizes in Industry Q will have decreased returns on sales and returns on total assets. However, an estimated 1.2 percent, market-adjusted price increase will mitigate much of the financial effects except for the extra-small model plants. A .96 percent decrease in industry-wide output is also projected with the proposed water pollution controls. Approximately two-thirds of this production decrease will result from four extra-small plants that are expected to close rather than comply with the proposed regulation. Approximately 160 jobs will be lost because of plant closures, affecting three communities--one small community will be substantially impacted, including secondary employment effects. Other effects are as indicated.

Table 30 summarizes this study's cost-effectiveness (C/E) analysis results, which are presented in more detail in the concluding section of this case study report. Once a level of control is specified, C/E analysis is an analytical technique for comparing regulatory alternatives. Its use in the early stages of a RIA will aid in reducing the number of alternatives which will require further analysis in a benefit-cost framework. As shown in Part A, ten regulatory alternatives, A to J, are depicted with their corresponding annualized costs and effects (tons of Pollutants X, Y and Z abated).

Table 28. Summary of undiscounted total social costs for the proposed Industry Q water pollution control regulation by year (1982 dollars)

Part A. Quantifiable/Monetizable Costs

	Year	Private sector real resource		Deadweight welfare		Government		Adjustment		Total costs 1/	
		Estimate	Range	Estimate	Range	Estimate	Range	Estimate	Range	Estimate	Range
		---millions of dollars---									
1	1982	80.5	72.8- 88.1	.0	.0-.1	.4	.4-.4	0	0	80.9	73.3- 88.6
2	1983	96.3	87.2-105.4	.1	.1-.1	.6	.5-.6	0	0	96.9	87.8-106.1
3	1984	112.2	101.6-122.9	.1	.1-.2	.7	.7-.7	.7	.6 -.8	113.8	102.9-124.6
4	1985	55.0	49.8- 60.3	.1	.1-.2	.5	.5-.5	.6	.6 -.7	56.3	51.0- 61.6
5	1986	55.0	49.8- 60.3	.1	.1-.2	.5	.5-.5	.5	.5 -.6	56.2	50.9- 60.5
6	1987	55.0	49.8- 60.3	.1	.1-.2	.5	.5-.5	.5	.5 -.6	56.2	50.9- 60.5
7	1988	55.0	49.8- 60.3	.1	.1-.2	.4	.4-.5	.5	.5 -.6	56.1	50.8- 61.4
8	1989	55.0	49.8- 60.3	.1	.1-.2	.4	.4-.5	.5	.5 -.6	56.1	50.8- 61.4
9	1990	55.0	49.8- 60.3	.1	.1-.2	.3	.3-.3	.5	.5 -.6	56.0	50.7- 61.3
10	1991	57.1	51.6- 64.5	.1	.1-.2	.3	.3-.3	.5	.5 -.6	58.0	52.5- 63.5
11	1992	59.0	53.2- 64.6	.1	.1-.2	.4	.4-.4	.5	.5 -.6	60.1	54.2- 65.8
12	1993	60.9	55.2- 66.7	.1	.1-.2	.3	.3-.3	.5	.5 -.6	61.9	56.0- 67.8
13	1994	60.9	55.2- 66.7	.1	.1-.2	.3	.3-.3	.5	.5- .6	61.9	56.0- 67.8
14	1995	60.9	55.2- 66.7	.1	.1-.2	.2	.2-.2	.5	.5 -.6	61.8	55.9- 67.7
15	1996	60.9	55.2- 66.7	.1	.1-.2	.2	.2-.2	.5	.4- .5	61.8	55.9- 67.7
16	1997	60.9	55.2- 66.7	.1	.1-.2	.3	.3-.3	.5	.4- .5	61.9	56.0- 67.7
17	1998	60.9	55.2- 66.7	.1	.1-.2	.3	.2-.3	.5	.4- .5	61.8	56.0- 67.7
18	1999	60.9	55.2- 66.7	.1	.1-.2	.2	.2-.3	.5	.4- .5	61.8	56.0- 67.7
19	2000	60.9	55.2- 66.7	.1	.1-.2	.1	.1-.1	.5	.4- .5	61.7	55.9- 67.6
20	2001	60.9	55.2- 66.7	.1	.1-.2	.1	.1-.1	.5	.4 -.5	61.7	55.8- 67.6

Part B. Nonquantifiable Costs

- Positive employment effects (compensating benefits): in the construction industry, to install the required equipment, and in Industry Q itself, to operate and maintain the equipment each year.
- Community effects in one small, rural community will cause substantial long-term costs in secondary markets.

1/ The sum of the individual costs may not equal the total costs due to rounding errors.

Table 29. Summary of economic impacts from the proposed water pollution control regulation in Industry Q

A. Financial Effects

- Average reductions in returns on sales (ROS) with pollution controls (no cost passthrough) are 3.0%, 1-5%, 1.3%, and 1.3% for the extra-small, small, medium and large model plants respectively; RCS reductions (with predicted passthrough are: 2.4%, .9%, .8%, and .7%, respectively.
- Returns on total assets (ROTA) are reduced with pollution controls from 9.1% for the extra-small model plant to 4.3% for the large model plant.
- Annual cash flows remain positive with water pollution controls for all four model plants throughout the 20-year planning period.
- Net present values (NPV) are positive at the cost of capital discount rate for all plants under the baseline (without pollution controls) conditions; however, the extra-small model plant's 20-year NPV is negative with pollution controls. One-third of the industry's plants represented by this model plant are projected to close (total of four plants

B. Price Effects

- The price increases required by each of the model plants to maintain their baseline profitability levels after pollution control costs are borne are the following: extra-small, 4.04; small, 2.1%; medium 1.9%; and large, 1.8%.
- An industry-level price increase of 1.2% is projected following marker equilibrium adjustments.
- A sensitivity analysis of pollution control costs shows that only the extra-small model plant would" be affected measurably by relatively small changes (±10 percent) in the pollution control investment and annual operating costs.

C. Production Effects

- A 0.96% reduction in Industry Q's aggregate production is forecast following the imposition of pollution controls.
- Four of twelve extra-small plants are projected to close, accounting for approximately two-thirds of the short-term reduced industry output. The balance of the reduced industry-wide production will be distributed among the remaining plants--theoretically in proportion to changes in the various-sized model plants' marginal cost curves.

D. Employment Effects

- Even with the projected price passthrough, a loss of 160 jobs is forecast in Industry Q as a result of the closure of the four extra-small plants (based on an average of 40 employees per plant). No layoffs are projected in the remaining plants even though total production will decrease marginally.
- Positive employment effects are also expected: (1) 550 work years of short-term construction industry employment will be required to install the pollution controls, and (2) 263 long-term employees will be required to operate and maintain the added pollution controls each year (this will over time, be the largest source of positive employment effects).
- Secondary employment effects are projected which include the loss of five jobs resulting from a local raw material supplier plant closing and the loss of 20 jobs in service-related businesses in Region 2, Community B, an area which is projected to realize two plant closings.

E. Community Effects

- Three specific communities will be affected by the projected plant closings.
- Tie community effects range from being relatively minor (in a large, urban community where most effects are short-term and alternative employment opportunities are available) to being extensive (in one small, rural community where substantial long-term effects are forecast and approximately one-fourth of the employees must relocate to find alternative employment).

F. Other Effects

- International trade effects will be minor.
- Energy requirements will increase by about 5% in industry Q, but this represents less than 0.1% of the total energy used in the study regions.
- No negative productivity effects are projected.
- Intergenerational effects include long-term health damages that will be mitigated with the proposed regulation.

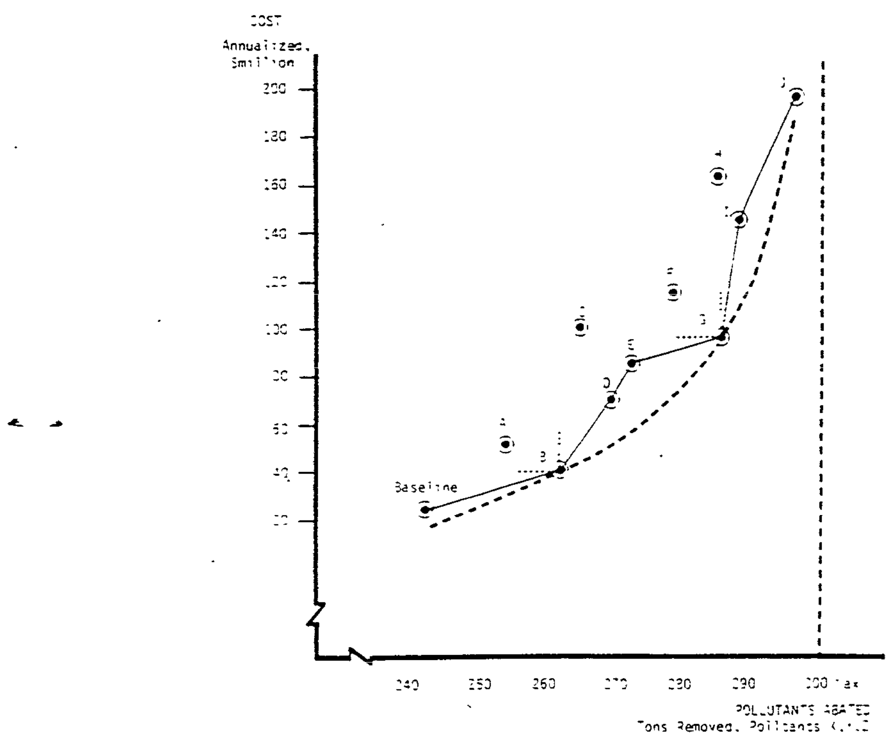
Table 30. Cost-effectiveness analysis summary results for the proposed water pollution control regulatory alternative versus other alternatives, industry Q

Part A. A. Cost-effectiveness values

Regulatory alternative	cost 1/	Pollution abated 2/	C/E value 3/	Comment 4/
	($ million)	1,000 tons)	($/ton)	
Baseline	23.0	242	95	Status without proposed regulation
A	30.0	255	118	Inferior to B
B	20.0	263	76	In least-cost C/E set
C	80.0	265	302	Inferior to D, E and G
D	50.0	270	185	In least-cost C/E set
E	68.0	273	249	In least-cost C/E set
F	96.0	280	343	Inferior to G
G	79.0	285	277	in least-cost C/E set
H	141.0	285	495	Inferior to I
I	128.0	287	446	In least-cost C/E set
J	180.0	295	610	In least-cost C/E set

Part B. Graphic display of C/E analysis

Figure 7. Cost-effectiveness of the proposed water pollution control regulation (Alternative G) compared to other selected alternatives



1/ Annualized total cost of abatement (pollutant removal) for each specified regulatory alternative.

2/ Total tons of pollutant abated (effect) for each specified regulatory alternative.

3/ Cost divided by tons of effluent abated. Note that other C/E measures should also be defined (such as the incremental cost above baseline and the incremental effluent abated above baseline) which will more closely represent the (theoretically preferred) marginal cost effectiveness for each alternative.

4/ An inferior alternative is neither less costly nor more effective than the indicated (or dominant) alternative(s).

Four of the 10 alternative regulations were shown to be "inferior" to one or more of the remaining "dominant" alternatives using only cost-effectiveness analysis. The set of dominant alternatives form the least cost envelope curve as depicted in Table 30, Part B. Benefit-cost analyses are required for each of these alternatives to determine which level of effectiveness will provide the greatest net social benefit. Such a comparison (using hypothetical results) is shown in Section G.

The remainder of this report reflects a benefit-cost analysis of a single regulatory alternative: in particular, Alternative G, as defined in Table 30. Similar benefit-cost analyses are applicable for all cost-effective alternatives that form the so-called least cost envelope curve as illustrated in Table 30, Part B. However, for illustrative purposes, it was deemed necessary to summarize only the benefit-cost analysis for one (the preferred) regulatory alternative.

B. Background

The present study assumes that recent scientific evidence indicates that current effluent standards for certain pollutants produced by Industry Q may not be adequate to safeguard the natural environment exposed to these pollutants and to maintain the health and welfare of human populations. Consequently, further regulation of this industry is being examined, necessitating the analyses outlined in this case study.

To reduce the complexity of the case study, Industry Q is assumed to be located in only two regions (hereafter referred to as Regions 1 and 2). The streams and rivers in these regions receive effluents from Industry Q, containing Pollutants X, Y and Z at levels in excess of that required under the alternate BAT levels currently being examined for this industry. Though this case study focuses upon a relatively stringent set of these levels, the‘methods outlined can be used for most alternatives.

Region 1, primarily a large metropolitan area, contains 2,500,000 people, and its affected areas outside the urban area have, additionally, approximately 500,000 people. Industry Q establishments are primarily located in the region's metropolitan area and on the river which flows through its center. The industry's primary influence on the river is assumed to extend for approximately sixty miles, and Industry Q is but one of several industries which pollute the river. Located along the affected segment are such recreation facilities as several city parks, recreation areas, community marinas and boat club docks. Several industries currently take process water from this portion of the river. Most of the water for the municipal water system is taken upstream from the metropolitan area, and several Industry Q establishments are located along this portion of the river as well.

Region 2 consists of three smaller cities--A, B, and C--of fewer than 60,000 persons each. Industry Q, their major source of employment, has located its firms near the river which passes through these cities. The region's chief source of water pollution, Industry Q, affects the river for approximately 100 miles. This river is a major source of area recreation and provides the drinking water for all three cities.

C. Social Benefits

The major concerns which the analyst must address prior to performing a benefits analysis were outlined in the preceding air regulation case study (see Section II.C.); thus, they need not be repeated here.

The benefits associated with a water pollution regulation may be divided into the following five major effects: health, recreation, aesthetics-existence, diversionary use, and ecological. It is important that these categories be carefully defined to avoid overlap, particularly so for recreation since this effect may include recreational, aesthetic and ecological benefits as well. Consequently, when assessing this category, the analyst must separate out aesthetic and ecological benefits. 1/

The present case study utilizes the above five category division; however, the recreational category includes only instream activities such as fishing and boating. Activities such as hiking, picnicing, jogging, and camping are included in the aesthetic category. All five categories are outlined in detail in Table 31.

This section on benefits is further subdivided into six subsections. The first five each deal with one of the five categories of benefits outlined above. The last section examines benefit aggregation.

1. Health Effects

The previous air regulation case study outlined in detail the types of information necessary to estimate health benefits; however, because water is not as ubiquitous as air, the exposure pathway is perhaps of more concern for a water pollution control regulation than one for air pollution. control. Three primary exposure pathways exist for a water pollutant--drinking water, swimming, and eating seafood from polluted waters. Ideally, dose-response curves should be developed for each pathway, but, realistically, the health effects consequent to swimming in polluted water and to eating contaminated seafood cannot usually be quantified because such dose-response information is insufficient. 2/

This case study assumes that only Pollutant Z affects human health and that this pollutant does not accumulate in organisms eaten as food. Though the potential exists for human exposure through swimming, the data are unavailable to allow an assessment; thus, this health effect will remain unquantified for this case study.

Pollutant Z, a substance associated with kidney and liver disfunction, is most importantly, a known carcinogen, causing primarily urinary tract cancer. Currently, enough information is available for the Cancer Assessment Group, through the use of their model (in Federal Register November 28, 1980), to estimate a life-time cancer risk 70 years due to the presence of this pollutant at different levels of concentration in drinking water. The present study assumes that this information is

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1/ When measurement methods and available data prevent easy categorization by benefit category, the analyst may employ a weighted apportionment to distribute the pertinent benefits.

2/ A confounding factor in assessing the exposure threat from swimming is that once a swimming area is known to be contaminated, swimmers are less apt to visit it. Under such a condition, an exposure rate study becomes questionable.

Table 31. Types of effects and benefits resulting from reduction in water pollution

Major effect categories	Types of effects	Resulting benefits
I. Health	a. Reduced mortality	1. Increased length of life and reduced probability of death 2. Reduced pain and suffering
	b. Reduced morbidity	1. Reduced medical expenses 2. Reduced pain and suffering 3. Reduced work loss days 4. Increased productivity 1/
II. Recreation (instream)	a. Decreased visible pollution b. Decreased odor C. Increased sport fish populations	1. Increased enjoyment of swimming, boating and fishing 2. Increased number of areas available for swimming, boating and fishing
III. Aesthetic/existence	a. Decreased visible pollution b. Decreased odor	1. Increased enjoyment of being near water body 2. Increased satisfaction from knowing water in area is clean (existence) 3. Increased satisfaction from knowing water in area will be clean when used in the future (option)
IV. Diversionary uses	a. Reduced concentration of pollutants in intake water for municipal and commercial users b. Increased water available for irrigation	1. Reduced treatment costs 2. Decreased costs of agricultural production
V. Ecological 2/	a. Decreased damage to commercial species and crops 3/ b. Decreased damage to natural systems	1. Increased revenues for fishermen and farmers 2. Increased existence, option and preservation benefits

1/ Measured as "decreased work days of decreased employee lassitude."

2/ Note that a portion of this (i.e., increased sport fish populations) is included under recreation.

3/ Because of decreased pollution in irrigation waters.

available in the Criteria Document for Pollutant Z and that, in accordance with EPA guidance, this information will be used to estimate the number of cancer deaths and the concomitant medical expenses and foregone earnings which will be avoided if the reguatory alternative examined goes into effect.

While other physical effects (e.g., liver and kidney disfunction) are also associated with this pollutant, data are currently too sketchy to allow estimation of dose-response curves. Most appropriate epidemiology studies for this pollutant have been confined to the work place, where the dosage rate is much higher than that usually encountered in drinking water. This is also true of laboratory studies designed to examine this aspect of pollutant Z's health effects. Thus, these possible health benefits will also remain unquantified for this case study.

The remainder of this section on health effects will focus on estimation of benefits due to the avoidance of cancer incidence resulting from reduced concentration of, Pollutant Z in drinking water.

To assess the excess lifetime risk from cancer which residents in the affected region face from Pollutant Z, the concentration of this pollutant in the drinking water must be first established. The amount Industry Q contributes to this concentration must then be determined as well as the effect the proposed regulatory option will have on this contribution. This case study assumes the following:

- Many systems do not currently remove Pollutant Z, since only recently has its link with cancer been established and processes necessary to remove it are expensive.

- Industry Q is the only source of Pollutant Z in both Region 1 and Region 2.

- Though Region 1 takes its water upstream from the metropolitan area, several Industry Q plants are located upstream. Drinking water samples indicate a concentration of Pollutant Z such that the Cancer Assessment Group estimates the excess lifetime cancer risk for persons drinking the water at 10^{-5} 3/. Currently, 2.9 million persons are served by this water system. Other residents (100,000) in the counties near the river segment are assumed to obtain their water from wells or other municipal systems which will be unaffected by the regulation.

3/ This estimate as well as those for Region 2 may seem somewhat large. High estimates were used for illustrative purposes, such that when converted to an annual basis, the estimated number of deaths per year would not be very small fractions.

- In Region 2, City A, which is the farthest upstream, currently has no detectable levels of Pollutant Z in its drinking water since all Industry Q plants are downstream. Pollutant Z is detectable in City B's water at levels equivalent to an excess lifetime cancer risk of approximately 10^{-4}. City C, which is the farthest downstream, has the highest concentration in its drinking water and an excess lifetime cancer risk level of 1.5×10^{-4}.

- After the proposed regulation goes into effect, the concentration of Pollutant Z is expected to be below detection limits and the risk level is assumed to be close to zero in both regions.

Since EPA guidance suggests that benefits for the entire planning period,be stated also in yearly levels, the lifetime excess cancer risk should be translated into a yearly excess cancer risk. This can be accomplished by finding the roots (X) of the following 70th order polynomial:

$$0 = -L_{70} + \sum_{i=1}^{70} l_i (l-x)^{i-1} x \qquad (24)$$

where

L_{70} = excess lifetime (70 year) cancer risk as determined in the criteria document at the carcinogen's average concentration level in the drinking water.

l_i = fraction of population surviving to age i

X = annual excess cancer risk due to carcinogen in question

i = subscript denoting age

Since x is a probability, only real roots between 0 and 1 need be considered. Additionally, x must be less than L_{70}. For the present case study, the roots for equation 24 were solved numerically through the use of a computer program. The resulting estimates of x were as follows:

Region 1	1.579940×10^{-7}
Region 2, City B	1.580023×10^{-6}
Region 2, City C	2.370096×10^{-6}

Table 32 shows the estimated number of cancer incidents per year for the planning period by region. Since cancer is usually fatal, this study assumes that these cancer incident estimates represent the number of deaths avoided during the planning period.

Table 32. Cancer incidents avoided due to the proposed water pollution control regulation by year 1/

Year		Region 1	Region 2	Total Estimate	Total Range 2/
1	1982	.15	.05	.20	.16-.24
2	1983	.31	.11	.42	.33-.51
3	1984	.47	.16	.63	.50-.76
4	1985	.47	.17	.64	.51-.77
5	1986	.48	.17	.65	.51-.79
6	1987	.48	.18	.66	.51-.81
7	1988	.49	.18	.67	.51-.81
8	1989	.49	.18	.67	.51-.81
9	1990	.50	.18	.68	.51-.81
10	1991	.50	.18	.68	.51-.81
11	1992	.51	.19	.70	.52-.82
12	1993	.51	.19	.70	.53-.83
13	1994	.52	.20	.72	.53-.83
14	1995	.52	.20	.72	.58-.90
15	1996	.53	.21	.74	.58-.90
16	1997	.53	.21	.74	.58-.90
17	1998	.54	.21	.75	.58-.90
18	1999	.54	.22	.76	.58-.92
19	2000	.55	.22	.77	.58-.92
20	2001	.55	.23	.78	.59-.93
Total for Planning Period		9.6	3.6	13.2	10.2-16.0

1/ In constant 1980 dollars.

2/ To reduce the complexity-of the table, the ranges for most entries are not shown. These can be easily calculated for each value, however, since a percent variation around the point estimate was assumed for each benefit type (i.e., 20% and 25% for Regions 1 and 2, respectively). Only the ranges of grand total values are shown.

The next step in evaluating decreased carcinogen concentration benefits requires translating cancer incidents into medical costs and earnings foregone. The procedure is similar to that outlined in the air pollution control regulation case study for determining medical expenses and work loss days. The type of information needed to obtain medical costs and estimated earnings foregone includes:

- Employment and housekeeping participation (males and females keeping house without pay) rates by age
- Mean annual earnings of employed individuals and mean household labor values by age and sex
- Survival rates for specific types of cancer patients for at least 15 years after diagnosis
- Life expectancies for cancer patients by cancer type and cross tabulated by age and sex
- General survivorship curve for population of interest (ages 0-70 4/, by year)
- Age distribution for population of interest (ages 0-70, by year)
- Mean number of patient lost workdays, per year, by cancer type
- Medical costs (including costs for physicians, hospitalization, drugs, tests, private nursing, special treatment and therapy, nursing home and attendant care, special equipment and prosthetics, etc.) by year for each year after diagnosis by age and sex (if available).

Most of the information utilized in the present case study was obtained from Hartunian, et al. (1981). For most RIA's which include cancer impact effects; these information requirements may not be sufficiently detailed. Hartunian, et al., contains an extensive bibliography on studies relevant to estimating lowered cancer incident benefit. Included among the more pertinent are: Abt Associates, Inc. and Boston University Cancer Research Center (1976), American Cancer Society (1975a+b, 1977), Axtell, Cutler and Myers (1972), Axtell and Myers (1974), Cutler, et al. (1974), Cutler and Young (1972), and Scotto and Chiazze (1976).

In the present study, the estimated number of excess cancer deaths per age class and for each year of the planning period was calculated using the yearly excess cancer risks given above. To do this, the study assumed that

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4/ 70 = expected normal lifetime

the incidence rate did not vary by age class. 5/ For each incidence rate, the patient's time of death was determined from age-specific survivorship rates for kidney cancer.

Yearly averages of total medical expenses were determined on the basis of a computer program which utilized kidney cancer cost data from Hartunian, et al. (1981). The program considered the planning period's yearly total medical expenses per cancer incident from the year of detection to the year of death as determined by age distribution and cancer risk rate schedules. For those incidents assumed to occur during the latter years of the planning period, expenses up to and through the last planning period year only were included. The results of the program's calculations are presented in Table 33.

To calculate worker earnings foregone after cancer diagnosis, the following equation developed from Hartunian, et al. (1981) was utilized:

$$EF = \sum_{n=m}^{k} WLEF(n) + \sum_{n=k}^{j} ADEF(n) \qquad (25)$$

where

EF = Earnings foregone per cancer incidence

WLEF(n) = earnings foregone during a cancer patient's life per year due to work loss days for a person of age n

ADEF(n) = earnings foregone by a cancer patient due to premature death for a person of age n

n = age

m = specific age at cancer diagnosis

k = specific age of premature death due to cancer

j = average age at death for overall population

WLEF(n) and ADEF(n) are calculated as follows:

$$WLEF(n) = \alpha_{q\,i} \cdot Y(n) \cdot E(n) \qquad (26)$$

5/ The assumption is likely to be invalid since cancer incidence usually does vary by age class; however, not enough information is available from the excess cancer risk estimate to allow any other assumption.

Table 33. Health benefits due to the proposed Industry Q water pollution control regulation by year 1/

	Year	Medical expenses	Foregone earnings	Total	
				Estimate	Range 2/
1	1982	1,203	2,162	3,365	3,005- 3,725
2	1983	2,445	4,421	6,866	6,131- 7,601
3	1984	3,726	6,780	10,506	9,381- 11,631
4	1985	5,050	9,242	14,292	12,762- 15,822
5	1986	6,416	11,830	18,246	16,293- 20,199
6	1987	7,825	14,514	22,339	19,949- 24,729
7	1988	8,629	17,561	26,198	23,399- 28,981
8	1989	8,804	20,697	29,501	26,375- 32,627
9	1990	8,981	24,540	33,521	29,989- 37,053
10	1991	9,160	28,448	37,608	33,664- 41,552
11	1992	9,345	33,268	42,613	38,165- 47,061
12	1993	9,532	38,166	47,698	42,737- 52,659
13	1994	9,724	44,288	54,012	48,416- 59,608
14	1995	9,920	50,519	60,439	54,197- 66,681
15	1996	10,119	56,863	66,982	60,082- 73,882
16	1997	10,322	64,917	75,239	67,508- 82,970
17	1998	10,530	73,120	83,650	75,074- 92,226
18	1999	10,742	81,469	92,211	82,776- 101,641
19	2000	10,958	91,562	102,520	92,049- 112,991
20	2001	11,178	101,976	113,154	101,615- 124,693

1/ Expressed in constant 1980 dollars.

2/ To reduce the complexity of the table, the ranges for most entries are "not shown. These can be easily calculated for each value, however, since a percent variation around the point estimate was assumed for each benefit type (i.e., 12 percent and 20 percent for medical expenses and foregone earnings, respectively). Only the ranges of the grand totals are shown.

where

$\alpha_{q,i}$ = proportion of year lost by cancer patients due to their illness for cancer type q for the ith year of their illness. 6/

Y(n) = the mean annual earnings of employed people and homemakers in the general population of age n

E(n) = the proportion of the general population of age n employed in the labor force or engaged in housekeeping tasks

$$ADEF(n) = P_k(n) \cdot Y(n) \cdot E(n) \cdot (1=\gamma) \qquad (27)$$

where

$P_k(n)$ = the probability of a person in the general population of age k living to age n

Y(n) = defined in equation 26 above

E(n) = defined in equation 26 above

γ = average annual rate of growth in labor productivity 7/

k = age at death

n = number of years beyond the year for which wage level is expressed in

A computer program calculated--for each year of the planning period--the amount of earnings foregone through the use of (1) the age-specific excess cancer incidence rate for each year of the planning period, (2) the expected survivorship by age class for persons having kidney cancer, and (3) equations 25-27. Earnings lost due to premature death and work loss days which would occur beyond the twentieth year of the planning period were not included. The results of these calculations are shown in Table 33.

2. Recreational Effects (Instream)

Three types of recreational user benefits can result from improvement in water quality: (1) decreased costs for users (i.e., reduced travel time

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6/ The case study assumed that this proportion was the same as the first year for every year until the year of death since information was not available in Hartunian, *et al.* (1981) for years beyond the first.

7/ Assumed to be 1 percent for this case study.

and expenses) as recreational sites closer to users residences become available, (2) increased use by existing and new users of water-based recreation activities (primarily fishing, swimming and boating), and (3) existing user benefits resulting from improved recreation facilities (Abel, Tihansky and Walsh, 1975). Two approaches can measure these benefits--willingness-to-pay or participation models. The use of the willingness-to-pay approach (i.e., contingent market techniques) was discussed in the visibility section of the air pollution case study and will not be reexamined here. 8/ The participation model is discussed below.

Jo estimate the benefits of instream recreation for a given regulation using the participation model, the following information is necessary:

- an estimate of the number of additional sites or the increased acreage available for water-based recreation due to the regulation

- knowledge of the relationship between the recreation behavior of consumers and changes in water quality

- the value to the consumer of water based recreation activities.

For the first of these requirements, a water quality model for the site in question is ideal. Such a model will estimate water quality levels with and without regulation of a given industry and will take into account other sources of pollution and their growth during the planning period.

The changes in water quality estimated from the water quality models will provide an estimate of the increased areas available for recreation. Because different levels of water quality 9/ are required for different types of recreation, this assessment is usually done by recreation type--(i.e., fishing, boating and swimming). Increased demand levels for each recreational activity are then calculated. These estimates should

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8/ For examples of this technique's use in estimating recreation benefits, see Gamlich, 1977; Walsh et al., 1978; Greenley et al., 1980; and Mitchell and Carson, 1981.

9/ The extent of user activities, of course, is dependent upon a broad range of water quality characteristics that are specifically related to particular recreational activities. Fishing, for instance, is partially dependent upon the number and types of an area's fish population and this reflects such water characteristics as the level of dissolved oxygen, pH, and solids and such aesthetic characteristics as turbidity and odor. Boating, on the other hand, is primarily influenced by aesthetic considerations.

take into account the socioeconomic characteristics of the population likely to take part in these activities as well as other recreation areas available to this population. (Examples of recreation demand models include: Davidson et al., Cicchetti, 1973; Clawson and Knelsch; Deyak and Smith, 1978; and Vaughan and Russell, 1981.) Increased demand is often expressed as increased activity days and is valued using a travel cost or willingness-to-pay approach. Examples of studies using these methods include: Burt and Breuer, 1971; Abel, et al., 1973; Walsh et al., 1978; Vaughan and Russell, 1981; and a forthcoming analysis of the Monongahela River basin, from Research Triangle Park, N.C.

This case study assumed that the study regions' rivers are primarily used for fishing and boating (little swimming occurs in each due to the unsuitability of these rivers for this activity--banks too steep, rocky bottoms, etc.). The regulatory alternative considered in this case study is expected to increase the number of areas available for both fishing and boating. The following two sections discuss the resulting benefits.

a. Fishing benefits

Fishermen are sensitive not only to the supply of fishable water but also to the type of fish available in given areas. Obviously, any estimate of user benefits for fishing must be complex to account for such variables as water quality levels, their effects upon fish species and numbers, the relationship of fish species and user preferences, and the relationships between the demographic characteristics of fisherman and their use of fishing areas. A model developed by Vaughan and Russell (1981) takes such factors into account using relatively recent data. This model was chosen to estimate the fishing benefits for this case study. 10/

The Vaughan and Russell model, while data constraints prohibited estimation of willingness-to-pay, has been widely used. It is complex, consisting of twenty-nine different variables, over sixty coefficients and seven equations. (The model is only briefly described here.) Table 34 is a variables list displayed for illustrative purposes.

The Vaughan and Russell model consists of three stages. In the first, the probability that the average person will be a fisherman is estimated by taking into account such variables as age, income, sex, place of residence, and amount of fishable acreage available.

10/ The manner in which this model is utilized in this case study is probably not an optimal use of the model. This model was developed for the nation as a whole; hence, its use in a regional case study such as the present one somewhat limits its predictive accuracy. Ideally, a gravitational model should be used for such an application; however, such models, usually are fairly complex, and often do not specifically address given recreation types or take into account water pollution levels. (An example of a gravitational model which does take into account pollutant levels is Stern (1973); however, this model predicts overall recreation demand rather than levels by activity type.)

Table 34. List of Variables for the Vaughan and Russel Model

Variable Type	Variable Number	Variable Name	Definition	Stage of use
Dependent	1	P_f	Probability of being a fisherman	I
	2	P_T	Probability of doing some cold water game fish angling	II
	3	P_B	Probability of doing some warm water game fish angling	II
	4	P_R	Probability of doing some rough fish angling	II
	5 6 7	TROUTDA BAPADA ROUGHDA	Days spent per person per season freshwater fishing for cold water game fish (TROUTDA warm water game fish (BAPADA), and rough fish (ROUGHDA)	III
Independent	8	AGE	Average -age in years	I, II, III
	9	AGESQ	Age squared	I, II, III
	10	INCH	Average income in 1975 dollars	I, II, III
	11	SEX	Proportion of population which is male	I, II, III
	12	METRO	Proportion of population living in metropolitan areas	I, II III
	13	INCPER	Average income per household member	I
	14	HEAD	Proportion which are head of household (Dummy variable)	I
	15	PREF	Indicates preference for fishing over other wildlife associated sports (Dummy variable)	III
	16	WEST	Indicates residence in Census West Region (Dummy variable)	I
	17	CENT	indicates residence in Census Central Region (Dummy variable)	I
	18	SOUTH	Indicates residence in a Census South Region (Dummy variable)	I
	19	COAST	Indicates if area has marine or Great Lakes Coastline (Dummy variable)	I
	20	INCRE	Total acreage of fishable non-Great Lakes freshwater per capita in region	I
	21	OUTACRE	1 if fishable acres per capita in boundary areas exceeds INACRE	I
	22	TBAG	Average number of cold water game fish caught per fishing day by respondents favoring the activity (Regional Average) from Survey	II, III
	23	BPBAG	Average number of warm water game fish/pan fish caught per fishing day by respondents favoring the activity (Regional Averages) from Survey	II, IIII

Continued . . .

Table 34. (Continued)

Variable Type	Variable Number	Variable Name	Definition	Stage of use
	24	CBAG	Average number of rough fish caught per fishing day by respondents favoring the activity (Regional Averages) from Survey	II III
	25	RFFBPSHR	Ratio of fishable freshwater acreage in state suitable for warm water game fish/ pan fish to total state fishable acres	I
Independent	25	RFFFRSHR	Ratio of fishable freshwater acreage in state suitable only for rough fish angling to total state fishable acreage	II
	27	RFFTRAC	Fishable freshwater acreage per capita in state suitable for cola rater game fish angling	III
	28	RFFBPAC	Fishable freshwater acreage per capita in state suitable for warm water game fish/ pan fish angling	II
	29	RFFRAC	Fishable freshwater acreage per capita in state suitable for rough fish angling	III

In stage II, the probability that the average fisherman will fish for a given fish type is estimated, with probabilities being estimated for cold water game fish, warm water game fish, and rough fish. This estimation takes into account the socioeconomic factors (age, sex, etc.), as well as the proportions of the fishable water which contain the three different fish types. The equations are constructed to account for competition between the fish types to account for the fisherman's demand. The final stage of the model estimates the number of participation days per fisherman per year for each fish type. Again, socioeconomic factors are taken into account as well as the number of acres of fishable water available for each fish type. The results of the three stages are combined as follows:

$$A_i = (POP) \times (P_f) \times (P_i | P_f) \times (D_i) \text{ days for fish type} \tag{28}$$

where

A_i = number of activity days, per year per fisherman spent fishing for fish type i

Pop = the population likely using the waters in the region in question

P_f = probability of the average person being a fisherman

$P_i | P_f$ = probability of the average person fishing for fish type i given that that person is a fisherman

D_i = number of activity days per fisherman per year spent fishing for fish type i

i = indicates fish type (cold water game, warm water game and rough fish)

Vaughan and Russell valued activity day by fish type using a survey of fees applicable to fishing sites whose owners were asked the average size, number, and kind of fish caught, average distance traveled by patron, and other factors to control for differences in the quality of fishing experiences between sites. Charbonneau and Hay (1978) obtained very similar results using a survey asking fishermen about their willingness-to-pay for certain types of fishing.

The present case utilized the Charbonneau and Hay valuations because they are based directly on willingness-to-pay and because the valuation of a warm water game fish day could not be obtained directly from the survey used in Vaughan and Russell. The Charbonneau and Hay values, in 1980 dollars, are $26.61, $24.07, and $18.97 for cold water game fish, warm water game fish, and rough fish, respectively.

To use the Vaughan and Russell model to estimate the benefits resulting from a given regulatory alternative, the number of activity days for each fish type is estimated with and without the regulation. 11/ These estimates are subtracted from one another and multiplied by the appropriate activity day value.

The present case study assumed that a pre-study was carried out at fishing areas in Regions 1 and 2 to determine the population which would be affected by a change in water quality in the affected rivers. In each case, the population within the counties surrounding the rivers was found to be affected: in Region 1, 3 million people were affected; in Region 2, approximately 240,000. Other assumptions used to calculate the fishing benefits included:

- A population growth of 1 percent and 2 percent per year for affected populations in Regions 1 and 2, respectively, for the planning period.

- In Region 1, ten miles of the sixty miles of river affected by Industry Q will not change with regard to fishability since too many other sources of pollution exist in this segment. In the remaining fifty mile area, warm water fishing will resume, resulting in approximately an 11 percent increase in the acreage available for this type of fishing.

- In Region 2, the nonpoint sources of Pollutant Y will inhibit changes in water quality in ten of the river's affected one hundred miles; hence, current levels and types of fish will be constant in that ten mile area. The remaining ninety miles currently contain rough fish and with the proposed regulatory alternative, that river area will also maintain cold water game fish. This will result in close to a 20 percent increase in acreage available for cold water game fishing.

- Industry Q will not be in full compliance for three years, with one-third of the industry complying each year.

- Fish populations will not begin to recolonize until the third year (1985) after the preferred regulatory alternative goes into effect, and such colonization will take approximately one year, with most trout of fishable size two years after this (i.e., 1987), and most bass in about three years (i.e., 1988). A minor benefit level is shown prior to these years to indicate that some fish may reach fishable size earlier.

11/ The difference between the with and without regulation situations will be (1) the total number of fishable acres available, and (2) the acres available for each fish type.

- National averages for data on fishermen from Vaughan and Russell (1981) adequately reflect fishermen in the two regions.

The estimated fishing benefits are given in Table 35.

b. Boating

Participation approach estimates of benefits resulting from increased acreage available for boating require a model which relates water quality and boating demand; however, few such models exist. For this case study, the boating participation model developed by Davidson et al., 1966, will be utilized. Unfortunately, the Davidson study is dated and its water quality parameter is not as sensitive to pollutant level as is desirable for the current study's needs; it is, however, the most reasonable model for the present study.

The Davidson participation model relates socioeconomic characteristics and site quality to the probability of participation in boating. Assuming the socioeconomic characteristics of the region are independent of the proposed regulatory alternatives, this model can be expressed in the following form to allow an estimation of increased participation due to a change in water quality (Public Interest Economics Center and Office of Policy Analysis, U.S. Environmental Protection Agency, 1981):

$$\Delta PB = .38485 \times \Delta A + .03142 \times \Delta RFR \qquad (29)$$

where

ΔPB = probability of boating participation

ΔA = the change in water quality available for recreational boating expressed in acres per capita

ΔRFR = change in recreational facility rating

The RFR Term in the Davidson *et al.* model is a ranking scale for fishing facilities because information on boating was not available for that study's area; however, since the model's rankings were based on the availability and development of natural water facilities, its use for a boating model was qualitatively justified. The Davidson study assumption that elimination of pollution discharge produces a one point facility rating improvement is assumed also for the present case study.

To transform the probability estimated by Equation 25 into a benefit estimate, the following equation is needed

$$BB_{ij} = V \times Day_j \times POP_{ij} \times \Delta PB_{ij} \qquad (30)$$

Table 35. Instream recreation benefits due to the proposed Industry Q water pollution control regulation by year 1/

	Year	Fishing benefits Region 1	Fishing benefits Region 2	Fishing benefits Subtotal	Boating benefits Region 1	Boating benefits Region 2	Boating benefits Subtotal	Total Estimate	Total Range 2/
		-----------------	-----------------	-----------------	(thousands	of	dollars) -----------------	-----------------	-----------------
1	1982	0	0	0	3,620	363	3,983	3,983	2,788-5,178
2	1983	0	0	0	7,424	752	8,176	8,176	5,723-10,629
3	1984	0	0	0	11,192	1,144	12,336	12,236	8,635-16,037
4	1985	0	0	0	11,303	1,167	12,470	12,470	8,729-16,211
5	1986	0	28	28	11,414	1,190	12,604	12,632	8,844-16,420
6	1987	444	563	1,007	11,531	1,214	12,745	13,752	9,676-17,828
7	1988	8,961	575	9,536	11,661	1,238	12,899	22,435	16,181-28,689
8	1989	9,051	586	9,637	11,762	1,263	13,025	22,662	16,345-28,979
9	1990	9,141	598	9,739	11,880	1,288	13,168	22,907	16,606-29,292
10	1991	9,233	610	9,843	11,999	1,314	13,313	23,156	16,854-29,458
11	1992	9,325	622	9,947	12,119	1,341	13,460	23,407	17,038-29,776
12	1993	9,418	634	10,052	12,240	1,367	13,607	23,659	17,222-30,096
13	1994	9,513	647	10,160	12,362	1,395	13,757	23,917	17,412-30,382
14	1995	9,608	660	10,268	12,486	1,423	13,909	24,177	17,602-30,752
15	1996	9,704	673	10,377	12,611	1,451	14,062	24,439	17,794-31,084
16	1997	9,801	687	10,488	12,737	1,480	14,217	24,705	17,990-31,420
17	1998	9,899	700	10,599	12,864	1,510	14,374	24,973	18,186-31,760
18	1999	9,998	714	10,712	12,992	1,540	14,532	25,244	18,384-32,104
19	2000	10,098	729	10,827	13,123	1,571	14,694	25,521	18,588-32,454
20	2001	10,199	743	10,942	13,254	1,603	14,857	25,799	32,806-18,792

1/ Expressed in constant 1980 dollars.

2/ To reduce the complexity of the table, the ranges for most entries are not shown. These can be easily calculated for each value, however, since a percent variation around the point estimate was assumed for each benefit type (i.e., 25 percent and 30 percent for fishing and boating benefits, respectively). Only the ranges of the grand total values are shown.

where

BB_{ij} = boating benefits for year i and region j

V = value of a boating day

Day_j = the number of days per year individuals who participate in boating use their boats (or canoes) on the river in region j

POP_{ij} = population in region j during year i

ΔPB_{ij} = change in probability of participating in boating for year i and region j (calculated in Equation 29)

i, j = subscripts indicating year (i) and region (j)

To calculate increased boating participation, the present-study assumed the following:

- The effluent from Industry Q produces odors and an undesirable water color in certain areas of the rivers in each of the affected regions. The water in certain portions is also slightly corrosive to boat hulls. According to stream model results, the proposed regulatory alternatives should eliminate these problems over most of the affected river area.

- The increase in boating acres per capita due to the regulatory alternative is .0006 and .0008 for Regions 1 and 2, respectively. 12/

- Boater surveys in each region indicated that the mean average number of days spent boating each year, were four days and five days for Regions 1 and 2, respectively.

- The National Planning Association (1975) estimate that the value of a boating day is equal to 1.2 times that of a fishing day applies to the two study regions. (For the calculations, 1.2 times the value of warm water game fish activity day was utilized.)

The results of the calculations are shown in Table 35.

12/ These are assumed to have been developed through a survey of the affected areas as well as through the use of a water quality model. The results shown were based on estimates reported by the Public Interest Economics Center and Office of Policy Analysis, U.S. Environmental Protection Agency (1981).

3. Aesthetic and Existence Effects

This section examines four benefit types--out-of-stream recreational, option, existence, and bequest benefits. The first includes those aesthetic benefits from water-enhanced, out-of-stream recreational activities (e.g., picnicking, hunting, jogging; hiking) which result because nearby lakes and streams are clean. Option value (or option benefits) represents the benefit an individual receives from preserving the option to use a scarce resource (e.g., a river) in the future when there is some doubt as to whether this resource will be available at that time. Existence benefit denotes that value derived from the public's knowledge that the water quality of given water body is currently maintained even though any given individual does not necessarily expect to visit the site. Bequest benefit indicates that value which an individual places upon knowing that future generations will be assured of an adequate supply of potentially scarce resources (Walsh, et al., 1978).

The methods for valuing such benefits were examined in the visibility section of the air pollution case study; hence, they need not be repeated here. And, as in that section, a contingent market approach will be utilized to value these benefits.

The present case study assumes that a series of carefully designed contingent market surveys were conducted in the two regions. (See Rowe and Chestnut, 1981, and Mitchell and Carson, 1981, for a discussion of the bias difficulties that affect such surveys.) The calculation methods used for benefit variation were simplified since the bid value was assumed not to vary by income or other socioeconomic characteristics. In an actual study, calculations would be performed for each socioeconomic grouping and then summed. Examples of such equations are shown in the visibility section of the air case study.

Respondents in each region were shown a series of photographs which illustrated what the river in their region would look like with and without the proposed regulatory alternative. The respondents were also informed that the odor from the river which sometimes pervades certain city and municipal parks would be eliminated.

It is worth noting that contingent market surveys are expensive and time-consuming, and may often not be possible within existing resource constraints. Existing studies could be used to estimate willingness to pay in lieu of an actual survey if funds are limited. However, such bids tend to be site specific and the estimates for one area may not adequately reflect those of another area. Another approach might be to use actual markets as proxies (e.g., property values) as outlined in the water pollution case study. Care must be taken in using such an approach, since it is sometimes difficult to define exactly which benefits are being measured.

a. Out-of-stream recreational benefits

To estimate out-of-stream recreational benefits, respondents who currently (within the last five years) take part in activities which the rivers serve to enhance (e.g., picnickers, joggers, residents living on or near the rivers) were isolated. These respondents (hereafter referred to as aesthetic respondents) were asked how much they would pay per household to have the pollution in the river reduced to produce the effects shown in the photographs and described in the survey.

The out-of-stream recreational benefits shown in Table 36 were estimated assuming the following:

- The parks or recreational areas in the affected portion of the rivers in Regions 1 and 2 attract no users from outside the regions.
- Region 1 and 2 respondents will pay on the average approximately $25 and $20, respectively, per household per year to achieve the water quality concomitant with the proposed regulatory option.
- Only 60 percent of the households in Region 1 and 70 percent of the households in Region 2 take part in out-of-stream, water-enhanced recreational activities or live near the rivers.

b. Option benefits

To estimate option value the study asked respondents what additional amount they would pay to assure that the improved water quality would be maintained for their future recreational use. (Persons currently not using the river for out-of-stream recreation were also included in this portion of the survey since they could in the future take part in such recreation activity.) The average bid for both current users and nonusers was $9 per household, per year, for Region 1 and $7 per household, per year, for Region 2. The resulting benefits (assuming these bids) are shown in Table 36.

C. Existence and bequest benefits

To estimate existence and bequest benefits, those respondents currently not using the rivers for recreation and whose probability of future use was low were identified and questioned. (As was outlined in the visibility section of the first case study, this procedure helps to assure that there is little overlap among the four benefit types discussed in this section; see the visibility section for further explanation.) These individuals were asked, (1) how much they would pay to improve the water quality in the rivers in question though their probability of use is low and (2) what additional amount they would pay to assure that future generations could enjoy this same level of water quality.

The existence and bequest benefit estimates for Regions 1 and 2 are shown in Table 36. These were based on the following assumptions:

- The survey avoided bias and double-counting and contained a significant enough sampling of nonusers of the river.
- The average nonuser in Region 1 would pay $12 per household per year to improve the water quality of the river to the proposed level and $8 per household per year to assure this quality for future generations.
- The average nonuser in Region 2 would pay $10 per household per year to improve the water quality of the river to the proposed level and $6.50 to assure this quality for future generations.
- The annual fee cited by nonusers in each region would be a reasonable estimate of the existence and bequest benefits for all householders in the region.

4. Diversionary Use Effects

Diversionary use benefits are those which accrue to diverters of improved quality river waters. These benefits specifically include those for households (e.g., reduced water hardness), reduced public waterworks treatment costs, cost savings to industrial users of process and cooling water, and increased productivity for farms as greater volumes of clean water become available for irrigation. Quantifying such benefits may involve estimating (1) cost savings for public waterworks and industrial users, (2) willingness-to-pay or cost savings values for household use and (3) the values of consumer and producer surplus in the case where increased agricultural productivity has resulted. The procedures for quantifying these benefits are discussed in more detail below.

a. Public waterworks and industrial user benefits

To assess cost reductions for public waterworks and industrial users, analysts must first identify the potentially affected users. To do this, the following are needed:

- A stream model for assessing present and predicting future pollutant levels in the river with and without the proposed regulation. The models must consider the effects of all present and potential dischargers to the river, the region's present and future population levels, and the river's biological processes, stream flow, and weather effects stream flow.
- Knowledge of the location of all user influent pipes and of the user intake water pollutant levels before and after regulatory imposition.
- Information on the processing of the intake water by affected users.

Table 36. Out-of-stream recreational, option, existence and bequest benefits from the proposed Industry Q water pollution control regulation by year 1/

		Benefit type													
		Out-of-stream recreational			Option value			Existence			Bequest			Total	
	Year	Region 1	Region 2	Subtotal	Region 1	Region 2	Subtotal	Region 1	Region 2	Subtotal	Region 1	Region 2	Subtotal	Estimate	Range 2/
		thousands of dollars													
1	1982	5,396	403	5,799	3,237	201	3,439	4,317	288	4,604	2,878	187	3,065	16,907	12,398-21,416
2	1983	10,899	822	11,721	6,540	411	6,951	8,719	587	9,306	5,813	382	6,195	34,173	25,060-43,286
3	1984	16,512	1,257	17,770	9,907	629	10,536	13,210	898	14,108	8,807	584	9,390	51,804	37,990-65,618
4	1985	16,678	1,268	17,945	10,007	641	10,647	13,342	905	14,247	8,895	588	9,483	52,322	38,369-66,275
5	1986	16,841	1,308	18,149	10,105	654	10,759	13,473	934	14,407	8,982	607	9,589	52,904	38,796-67,012
6	1987	17,013	1,334	18,347	10,208	667	10,875	13,610	953	14,563	9,073	620	9,693	53,478	39,218-67,738
7	1988	17,183	1,361	18,544	10,310	681	10,990	13,746	972	14,719	9,164	632	9,796	54,049	39,636-68,462
8	1989	17,355	1,388	18,743	10,413	694	11,107	13,884	992	14,875	9,256	645	9,900	54,625	40,059-69,191
9	1990	17,528	1,416	18,944	10,517	708	11,225	14,023	1,012	15,034	9,348	657	10,006	55,209	40,487-69,931
10	1991	17,704	1,444	19,148	10,622	722	11,344	14,163	1,032	15,195	9,442	671	10,113	55,800	40,921-70,679
11	1992	17,881	1,473	19,354	10,728	737	11,465	14,304	1,052	15,357	9,536	684	10,220	56,396	41,358-71,434
12	1993	18,059	1,502	19,562	10,836	751	11,487	14,448	1,073	15,521	9,632	698	10,329	56,999	41,801-72,197
13	1994	18,240	1,533	19,773	10,944	766	11,710	14,592	1,095	15,687	9,728	712	10,440	57,610	42,249-72,971
14	1995	18,422	1,563	19,986	11,053	782	11,835	14,738	1,117	15,855	9,825	726	10,551	58,227	42,711-73,753
15	1996	18,607	1,595	20,201	11,164	797	11,961	14,885	1,139	16,024	9,924	740	10,664	58,850	43,159-74,541
16	1997	18,793	1,627	20,419	11,276	813	12,089	15,034	1,162	16,196	10,023	755	10,778	59,482	43,622-75,342
17	1998	18,981	1,659	20,640	11,388	830	12,218	15,185	1,185	16,370	10,123	770	10,893	60,121	44,092-76,150
18	1999	19,170	1,692	20,863	11,502	846	12,348	15,336	1,206	16,542	10,224	786	11,010	60,763	44,562-76,964
19	2000	19,362	1,726	21,088	11,617	863	12,480	15,490	1,233	16,723	10,326	801	11,128	61,419	45,044-77,794
20	2001	19,556	1,761	21,316	11,733	880	12,614	15,645	1,258	16,902	10,430	817	11,247	62,079	45,582-78,576

1/ In constant 1980 dollars.

2/ To reduce the complexity of the table, ranges are shown only for the yearly totals. Ranges for the other estimates can be easily calculated since a constant percent variation around the point estimate was assumed for each benefit type (i.e., 15%, 30%, 30%, and 40% for out-of-stream recreation, option value, existence and bequest benefits, respectively.

- Both before and after regulation costs 13/ for water taken from the river for each affected industry type and public waterworks.

Those users realizing a cost differential will, of course, benefit from the proposed regulation, and this benefit level, as stated earlier, is measured by the cost savings experienced. In performing this estimate, a generic approach (based upon user levels of needed water processing) likely can be used to reduce the complexity of the required data and calculations. cost savings estimates should be made for each year of the planning period. For future year estimates, population and industrial growth should be taken into account.

b. Householder benefits

To assess household benefits, pollutant levels in household water before and after regulations must be established to determine to what extent the proposed regulation has reduced their concentration. 14/ To assess the benefits of the determined reduction, estimates could be made of decreased householders' costs (e.g., reduced softener detergent, bleach costs). Benefits could also be measured through a householder's contingent market survey; however, the difficulty of describing the direct cost effects of pollutant changes to householders may significantly inhibit the value of such a survey.

c. Agricultural, industrial and waterworks benefits

To assess the consumer and producer surplus benefits which would result from increased amounts of irrigation water use, the method outlined in the ecological effects section of the air pollution case study should be utilized. The reader is referred there for further information.

The present case study assumes that the proposed regulation will result only in public waterworks diversionary benefits. Irrigation is not prevalent (nor needed) in either of the regions, and the affected pollutants are not of concern to the regions' industrial cooling waters. (The germane pollutants do affect certain types of industrial process water, however, in such cases, the affected industries will receive their water directly from public waterworks and will not reprocess it before use.) Finally, household present value benefits are presented also. No significant changes in household water pollutant levels will occur, though the costs to public waterworks to achieve those levels will be reduced.

13/ This will likely only include operation and maintenance costs.

14/ Reduced pollutant levels in household water are naturally of concern and are also measured under health benefits. Though municipal waterworks may not always remove such pollutants as chemicals recently classified as hazardous, industrial regulations may help reduce their concentrations. When such reductions are affected, they should be considered in the health benefits sector to avoid double-counting.

The diversionary use benefits shown in Table 37 were calculated using the following assumptions:

- The reduced pollutant levels for water treated in municipal systems will result in a longer period between regeneration times for the carbon used in the systems to remove organics.
- The municipal system in Region 1 (serving 2,900,000 people) utilizes carbon columns or activators; the affected systems in Region 2 use granular activated carbon systems.
- For reasons already discussed in the health section, only the systems in Cities B and C of Region 2 will be affected by the proposed regulations. These serve 33,000 and 44,000 individuals, respectively.
- System costs were based on Westin and Culp (1976) and Temple, Barker and Sloan (1977) estimates. The municipal systems in Region 1 were modeled after a system serving more than 1 million persons; those in Cities B and C were assumed to be similar to systems in areas with 10,000-100,000 persons. 15/
- All three systems would save approximately .01¢ per thousand gallons processed if the proposed regulation were in effect.
- Usage rate in both regions is approximately 150 gallons/person/-day. 16/

5. Ecological Effects

There are three primary types of ecological effects--commercial, recreational, and natural. Since the benefits of increased recreational fishing populations have already been assessed, they will not be discussed further here. The commercial and natural ecological benefits are discussed separately below.

a. Commercial effects

Two classes of commercial impacts can result from water pollution. The first results when polluted irrigation water causes crop damage. Lowered pollutant levels should reduce or eliminate such damage. The assessment of the resulting benefits would be similar to that outlined for air pollution

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15/ System costs were developed with the help of engineers from Pope Reid Associates.

16/ This usage rate estimate, taken from Metcalf and Eddie (1973), accounts for domestic, commercial, industrial and public water use, with the percentage breakdown of this estimate as follows: 10 percent, 18 percent, 24 percent and 17 percent, respectively.

Table 37. Diversionary use benefits due to the proposed industry Q water regulation by year 1/

	Year	Region 1	Region 2	Total Estimate	Total Range 2/
		---thousand of dollars---			
1	1982	524	14	538	484 - 592
2	1983	1,075	29	1,103	993 - 1,214
3	1984	1,620	44	1,664	1,498 - 1,830
4	1985	1,636	45	1,681	1,513 - 1,342
5	1986	1,652	46	1,698	1,528 - 1,868
6	1987	1,669	47	1,716	1,544 - 1,888
7	1988	1,685	47	1,732	1,559 - 1,905
8	1989	1,702	48	1,750	1,575 - 1,925
9	1990	1,719	49	1,768	1,591 - 1,945
10	1991	1,736	50	1,786	1,607 - 1,965
11	1992	1,754	51	1,805	1,624 - 1,986
12	1993	1,771	52	1,823	1,641 - 2,005
13	1994	1,789	53	1,842	1,658 - 2,026
14	1995	1,807	55	1,862	1,676 - 2,048
15	1996	1,825	56	1,881	1,693 - 2,069
16	1997	1,843	57	1,900	1,710 - 2,090
17	1998	1,862	58	1,920	1,728 - 2,112
18	1999	1,880	59	1,939	1,745 - 2,133
19	2000	1,899	60	1,959	1,763 - 2,155
20	2001	1,918	61	1,978	1,781 - 2,177

1/ In 1980 dollars.

2/ To reduce the complexity of the table, only the ranges for the yearly totals are given; however, the other ranges can be easily calculated since a constant percent variation around the estimate was assumed. (In this case a 10 percent variation was used for both regions.)

crop damage; however if the grower experienced more damage to his crops than irrigation benefited him in increased revenues, the grower would likely stop irrigating long before a regulation can be promulgated to reduce the pollution in the irrigation water. Consequently, some of these benefits would be considered diversionary use benefits as discussed in the diversionary use section of this case study.

Because a fairly lengthy discussion on this type of benefit analysis was already outlined for the air case study, none of the water from the affected portions of the rivers in each region is assumed to be used for irrigation purposes.

An additional commercial effect of water pollution is reduced commercial fish populations. Again, the assessment of this benefit resulting from reduced pollution would be similar to that outlined for crop damage due to air pollution except that a demand curve for the commercial fishery affected would be used in place of that used for the crop examined in the first case study. Estimates of fish population levels, both with and without the proposed regulation, for each year of the planning period would be needed to estimate the necessary supply curves. However, since little data on fish populations exist, an estimation of supply curves may be impossible in certain situations; thus, this benefit category may have to be left unquantified. Examples of studies for which bioeconomic modeling of a fishery has been attempted include: Blomo et al., (1978) and Blomo (1979).

Because commercial fisheries are often not found on smaller inland rivers, no commercial fisheries were assumed to exist on the river segments examined in this study.

b. Natural effects

Natural ecosystem effects result when pollutants significantly reduce plant and animal species and disrupt the functioning of aquatic communities. The types of benefits associated with these effects are primarily existence and bequest.

This case study assumed that an endangered species is located in the river in Region 2 and that the proposed regulatory option will considerably improve its chances of survival. To assess the regional benefits 17/ of improving the survival chances of this population, a survey was conducted in Region 2 asking (1) how much households would be willing to pay to see this improvement in survival probabilities for the endangered species population in the area and (2) what additional amount they would be willing

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17/ In the case of an endangered species or habitat, individuals outside the region may be concerned (i.e., conservationists); thus, this is another factor which should perhaps be assessed. Nonetheless, to reduce the scope of this case study, the benefits considered are those accruing to only the region in question.

to pay to help assure that this population would survive for future generations in the region. The resulting benefits are shown in Table 38 and were estimated by assuming that the average household in the region would pay $5 per year to assure the present survival of the endangered species and $3 to assure survival for future generations.

Where the expense and time involved preclude a survey approach, this benefit category will most likely have to be addressed qualitatively. Ranges of values from similar studies may be used as proxies when a more in-depth approach is not possible.

6. Aggregation of Benefits

The procedures for the aggregation of benefits was discussed in detail in the air regulation case study; hence, they need not be repeated here.

The benefits described in this water regulation case study were carefully defined to avoid benefit sector overlapping, thus, the benefits presented in the preceding subsections can be directly added. The results of such aggregation are shown in Table 26.

Table 38. Industry Q water pollution control regulations: ecological benefits associated with an endangered species by year 1/ 2/

	Year	Benefit type: Existence	Benefit type: Bequest	Total: Estimate	Total: Range 3/
		(Thousands of dollars)			
1	1982	144	86	230	142- 318
2	1983	294	176	470	290- 650
3	1984	449	269	718	444- 992
4	1985	453	272	725	449-1,001
5	1986	467	280	747	462-1,032
6	1987	477	286	763	472-1,054
7	1988	486	292	778	482-1,074
8	1989	496	298	794	492-1,096
9	1990	506	303	809	501-1,117
10	1991	516	310	826	511-1,141
11	1992	526	316	842	521-1,163
12	1993	537	322	859	531-1,187
13	1994	547	328	875	541-1,209
14	1995	558	335	893	553-1,233
15	1996	570	342	912	564-1,260
16	1997	581	349	930	576-1,284
17	1998	593	356	949	587-1,311
18	1999	604	363	967	598-1,336
19	2000	617	370	987	610-1,346
20	2001	629	377	1,006	622-1,390

1/ The species is located only in Region 2; thus, the benefits are for this region only. Persons living outside the region may be concerned about this species and might be willing to pay a certain amount to guarantee its survival; however, due to lack of information, these benefits were calculated on a regional basis only.

2/ In constant 1980 dollars.

3/ To reduce the complexity of the table, ranges only for the yearly totals are shown. Ranges for the other estimates can be easily calculated since a constant percent variation around the point estimate was assumed for each benefit type (i.e., 40% and 35% for existence and bequest benefits, respectively).

D. Social Costs

This section of the water quality regulation case study presents the social costs of implementing the most stringent of the proposed BAT guidelines for Industry Q. These costs are defined as the value of the goods and services lost by society resulting from (1) the use of private resources to meet regulatory compliance, (2) the reduction in output attributable to compliance, and (3) the use of government resources to implement a regulation. Past regulatory impact analyses usually focused only on those costs incurred by directly-affected private parties. The total social costs presented and discussed separately below, however, include (1) all private real resource costs (net of transfers), (2) dead-weight welfare. losses, (3) governmental regulatory costs, and (4) adjustment costs.

This study's estimates of the total social costs of regulatory compliance were determined within a static, partial equilibrium framework. Justification for this approach and a detailed explanation of its basic procedures were presented in the social costs section of the preceding air pollution control regulation case study. The present case study differs from those procedures only in its emphasis on those concerns specific to water pollution control regulation compliance and on those matters of social cost analysis not pertinent to the air pollution control regulation case study.

Throughout the following discussions of private sector real resource costs and adjustment costs, there are numerous references to the economic impact analysis, Section E. These references reflect the intricate nature of the social costs analysis which uses the findings of the economic impact analysis to extrapolate individual plant compliance costs estimates to aggregate industry costs.

The major interactions between the social costs analysis and economic impact analysis are reviewed below.

- The social costs analysis uses estimates of aggregate industry pollution abatement compliance costs as an approximate measure of private sector real resource costs. These industry costs are estimated by aggregating firm level compliance costs at the post-regulation level of production. Firm level compliance cost estimates are derived from engineering cost estimates of pollution abatement technologies. These firm level costs analyzed in the economic impact analysis to determine the price increase necessary to maintain the model plants' pre-regulation levels of profitability. The cost analysis incorporates these price increases into a market analysis of industry supply and demand to estimate the post-regulation level of production.

- The economic impact analysis, Section E, projects probable employment and plant closure impacts for the case where all compliance costs are absorbed by the firms and the case where the most likely price increase occurs. The adjustment costs analysis monetizes the employment and plant closure impacts for the worst case scenario, i.e., no pass through.

For this case study, the following industry-related assumptions were made:

- Industry Q is located only in Regions 1 and 2.
- The proposed regulation will require that new pollution abatement technology be added to existing (and new) manufacturing plants in both regions.
- No change will occur in the operating efficiency of the affected plants.
- Firms in the industry employ a single major process and are represented in the study estimates by a combination of extra-small, small, medium, and large model plants.
- Firms in the industry produce a single consumer good that is sold in a perfectly competitive market. 18/
- Model plant results will be aggregated to the industry level by multiplying each model by the applicable number of extra-small, small, medium and large plants in each industry.

The following four subsections detail the procedures applicable to determining the four types of social costs noted above.

1. Private Sector Real Resource Costs

For this study; private sector real resource costs were calculated by estimating investment costs, annual operating and maintenance costs, and any additional costs incurred by the private sector both prior to and following regulatory compliance. Compliance costs are thus used as a proxy for private sector real resource costs. The procedures for estimating compliance costs are well described by EPA and are similar to the procedures presented in the air pollution control regulation case study. The principal difference between the procedures applicable to air pollution control regulation cost studies and those employed in water pollution control regulation cost analyses is that those of the latter traditionally specify effluent guidelines and standards on an industry-by-industry basis while the air pollution control regulation cost studies traditionally examine the costs of regulating one pollutant emitted by any number of industries. This occurs as a result of the pertinent

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18/ For discussions on social costs analysis of oligopolistic, monopolistic, and intermediate markets, see Anderson and Settle, 1977; Bohm, 1973; and Gramlich, 1981.

legislation. In keeping with this approach, the water pollution control regulation cost analysis for this study is based on a specification of effluent limits for firms in only one industry.

Briefly, the costs of water pollution control regulation compliance are usually estimated in the following manner.

- The industry is segmented into process technology categories and the costs for regulating the appropriate pollutant effluents are determined for each such category.

- The industry is resegmented into representative sectors that reflect the economic environment of the industry, and model plants are developed for each sector. In modelling industries to measure the economic effects of pollution control costs, all factors which will cause firms to have different average costs, outputs, or impacts are considered.

- The compliance costs are estimated for each model plant.

- The model plant compliance costs are expanded to industry sectors by multiplying each model plant's costs by the number of its constituent plants in the industry. The total industry costs are then estimated by summing the costs for each sector.

Conventional cost analyses usually end with an estimate of total industry compliance costs. A total social cost analysis, however, goes on to estimate the market impact of pollution control compliance costs; that is, to estimate its resultant shifts in price and production. Changes in production affect the private sector real resource and adjustment costs, and changes in prices and outputs measure the deadweight welfare loss.

The remaining portion of this discussion of Private Sector Real Resource Costs discusses in detail the procedures for estimating private sector real resource cost and is organized is the following manner: (a) segmenting the industry, (b) cost estimation procedures, and (c) case study application.

a. Segmenting the industry

Industry segmentation is necessary in order to construct a representative number of model firms that in total would accurately represent an industry's supply conditions--those industry plant characteristics that result in industry firms having different average costs, outputs, or impacts as a result of pollution control requirements. Such characteristics include such industry firm variables as volume of sales, profitability, type of process, and firm location.

Such variables are needed in determining model plant pollution control costs. Because economies of size affect pollution control costs, volume of sales is an important variable for defining model plants. Smaller plants usually require larger price increases to offset such costs; hence, the effect of pollution control requirements will vary by plant size. Plants of different process types will often experience different impacts, for pollution control technology requirements and their consequent costs often vary for each process. Location may also impact on a plant's input or output costs through transportation or other regional factor charges. A plant's profitability is reflective of average plant costs, and the lower the profitability the greater is the potential negative impact of regulatory compliance costs.

Segmenting an industry and determining the appropriate number of model plants necessary to an analysis depend upon the industry and the required accuracy of the resultant estimates. Beyond this point, however, detailed industry knowledge is necessary to determine how much variation in an important variable one model plant can reasonably represent.

b. Cost estimation procedures

Once the model plants have been defined, variables such as output and input-prices (and, necessarily, pollution control technology costs) are incorporated into the model plant framework 19/ and shifts in supply are estimated for each model plant. Next, the model plant results are expanded to model industry segments by multiplying each model plant's supply curve by the number of similar plants in the industry. The results for all the industry segments are then summed to estimate the supply function for the entire industry. The difference in the baseline supply function and the supply function with the proposed water pollution control regulation enacted defines the probable shift in supply as a result of regulation. Theoretically, the shift in supply consequent to regulatory compliance will result from 1) shifts in the industry's plants' marginal cost curves attributable to compliance costs, and 2) the supply effects of the closures of plants which cannot viably support pollution control costs. A diagram of this market impact is shown in Figure 5. The supply curve without regulation represents the sum of the quantity each individual plant produces at each given price. Demand is determined exogenously. The shift in supply attributable to the control costs' required price increases among plants is shown as S'. The regulatory costs cause the individual firm's marginal cost curves to increase; thus, the industry curve increases as well. As production increases, plants with larger incremental costs enter the market (assuming economies of size in pollution control costs) and the difference in the baseline supply curve and the supply curve with regulation increases with the level of output.

The shift in supply attributable to plant closures is shown as S". Plants that close as a result of pollution controls usually have relatively higher average costs, and thus, are at the upper end of the supply curve. Due to the plant closures, that quantity which would have been produced by these

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19/ Section E, Economic Impacts, contains a more detailed discussion of the model plant framework and its use in estimating social costs.

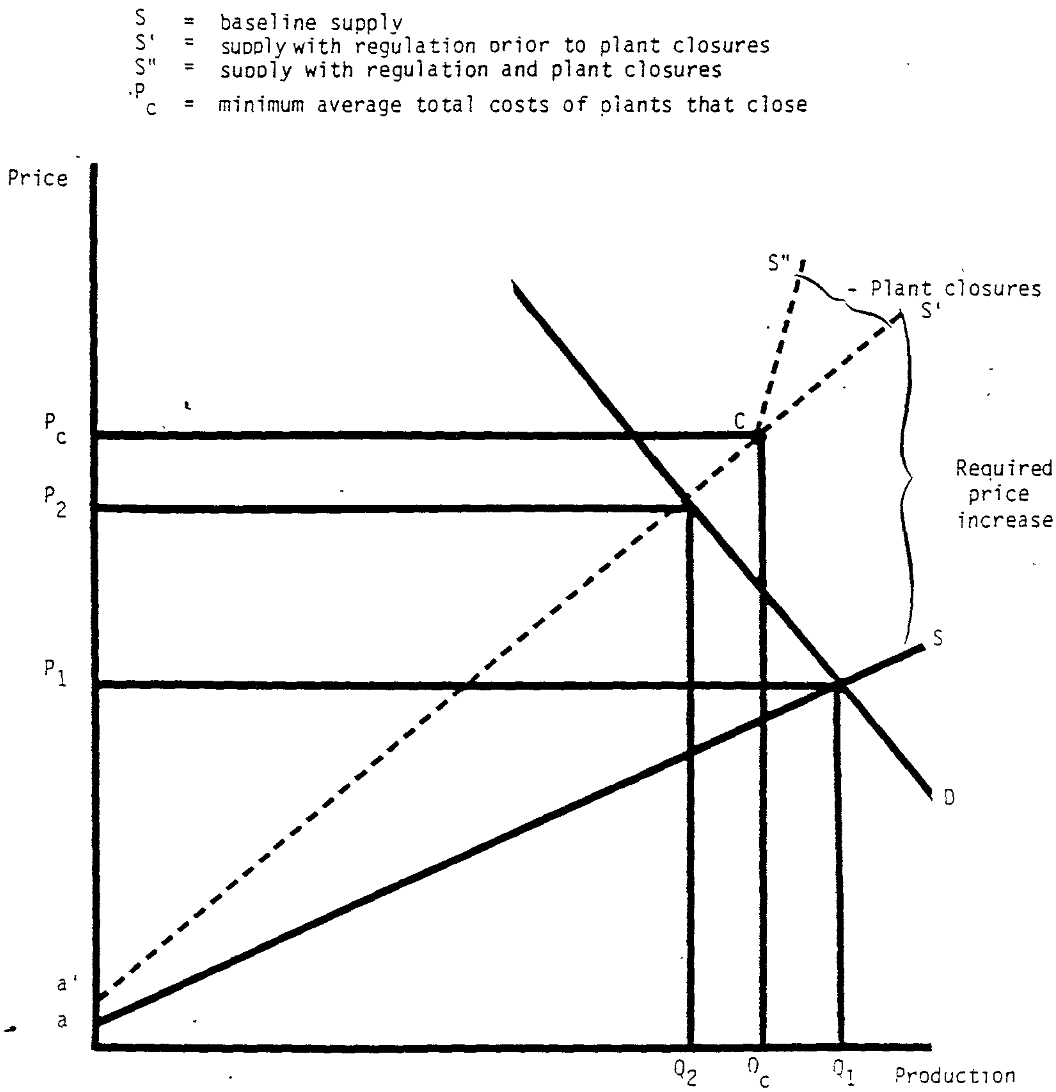

Figure 5. Illustration of supply shifts resulting from pollution control regulation.

firms is subtracted from overall market supply (although remaining firms are often able to increase production and thus absorb the otherwise lower output).

The analytic procedures described above require a knowledge of firms' (or model plants') specific marginal cost curves. For most regulatory analyses, however, this knowledge will not be available. Consequently, it will be necessary to approximate the effects of the individual plants shifts in supply on the industry supply function. In this case study, the effect is approximated by assuming the elasticities of the industry supply and demand functions have already been defined. In practice, available elasticity estimates should be obtained from existing studies (sometimes the opinion of industry experts can be utilized). If no estimates are available, sensitivity analysis can be performed over a "reasonable" range of assumed elasticities.

Knowing the elasticities and the current market equilibrium price and quantity, the industry supply and demand functions were then defined as nonlinear, constant elasticity functions of the following form:

$$P = axQ^b \qquad (31)$$

where

P = price

a = constant

Q = quantity supplied or demanded

b = exponential coefficient (inverse of the elasticity)

A graphic illustration of these functions is shown in Figure 6.

The shift in the supply function resulting from pollution control regulation can be estimated by determining the "required" price increase necessary to maintain the firm's profitability at the original equilibrium level of production and applying this increase to the original equilibrium price. The required price increase is traditionally derived in the economic impact analysis, Section E, by analyzing the firm's financial statements. Since all plants in the industry are assumed to be producing at the margin, this increase will be proportional to the marginal production rate of each plant at the market price. Most studies will not have the information necessary to estimate the marginal production rates (pre or post-regulation); thus, the industry price increase will have to be based solely on the model plants' required price increase. Two approaches to estimate the increase are: (1) a straight average of the model plants' price increases, and (2) a weighted average price increase based on each model plant's total production.

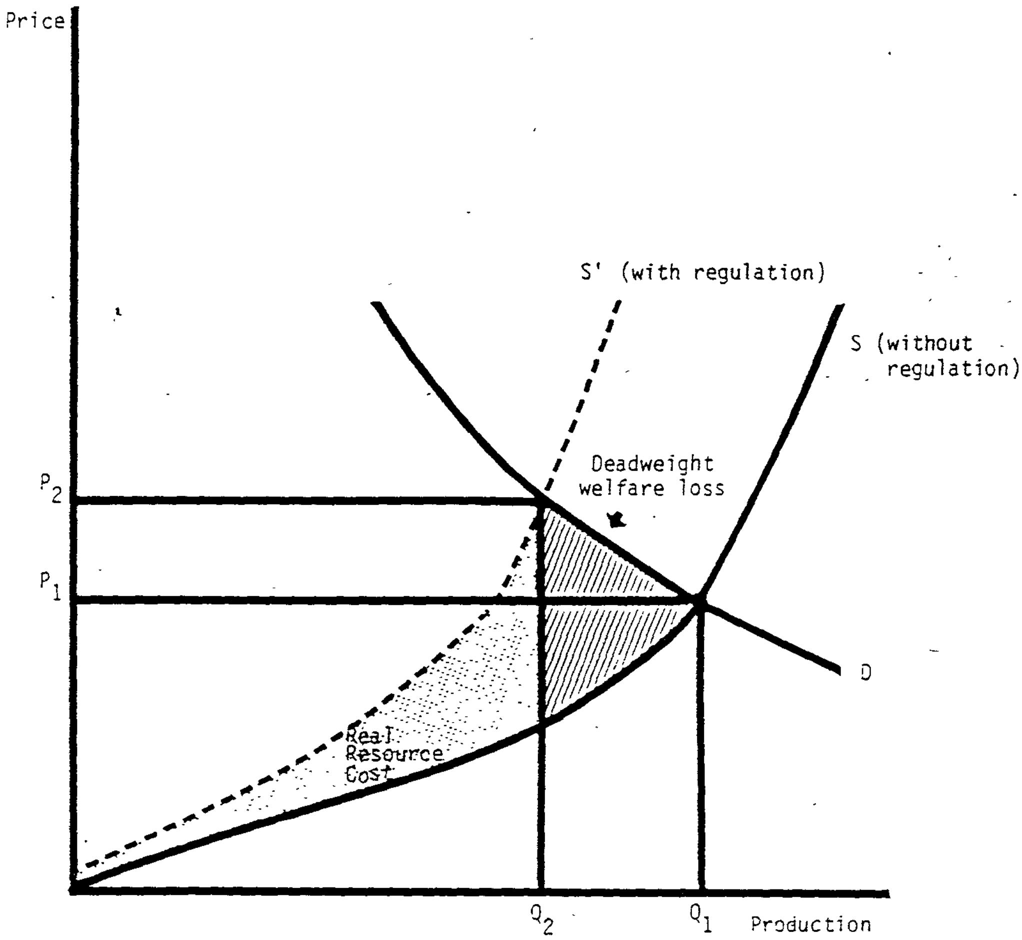

Figure 6. Illustration of shifts in Industry Qs supply function and market equilibrium resulting from water pollution control regulation.

Once the required price at the original level of production has been estimated (i.e., the original price plus the required increase), the exponential supply function with regulation can be estimated as the function that passes through this point defined by the original (i.e., only the elasticity changes). Market equilibrium with regulation is at the point where the supply function with regulation and the original demand function intersect, which is usually at a lower price and level of production.

c. Application to case study

The procedural framework discussed above is used in the present case study to estimate the probable market price and quantity impacts of the here considered industry water pollution regulation. The principal industry characteristic which will affect the Industry Q plants' responses to pollution control cost requirements is plant size; consequently, the plants in the industry were categorized by four size groupings -- extra-small, small, medium and large. The numbers of plants and their production characteristics by category are:

Sector	Number of plants represented	Model plant's annual production (million units)	Industry sector's annual production (million units)
Extra-small	12	.16	1.92
Small	20	.60	12.00
Medium	40	1.40	56.00
Large	15	2.00	30.00
TOTAL	87		99.92

The projected market equilibrium price without regulation is $25 per unit of production. Elasticity of supply and demand are +.96 and -.43, respectively.

The industry price and production levels were determined by analyzing current and projected market conditions. The industry supply and demand elasticities were derived from other sources. Based on these data, the variables of the baseline industry supply and demand functions are:

Supply: $a = 1.16 \times 10^{-7}$

$b = 1.041$

Demand: $a = 1.12 \times 10^{20}$

$b = -2.331$

The proposed water regulation will cause each plant in the industry to invest in and maintain pollution control equipment. The resultant pollution control costs (presumably determined in a previous study) are:

Industry sector	Investment cost per plant ($1000)	Annual O&M costs per plant ($1000)
Extra-small	580	200
Small	1,200	375
Medium	2,450	770
Large	3,400	1,020

As expected, pollution control costs are higher for each larger size of plant category and, also as expected, they increase at a decreasing rate, i.e., the costs per unit of production decrease as the plant size increases.

Each plant category's average price increase necessary to maintain pre-regulation profitability can be determined by applying the regulatory costs within an NPV analysis. (The applicable methodology used in the present study is outlined in Section E below.) The required price increases and changes in production for each plant category as a result of the pollution control requirements are:

Industry sector	Price without regulation ($)	Required price increase (%)
Extra-small	25	4.0
Small	25	2.1
Medium	25	2.0
Large	25	1.8

Applying the resulting price increases for each category to the quantity of output in the baseline supply function determines the projected shift in the supply function and the regulation-induced shift in production and prices. This case study used the average of both the straight average and production-weighted average price increases. A graphic representation of the shift in supply is shown in Figure 6. The elasticity of supply will decrease to +.959 and the variables of the supply function with regulation will be:

Supply with regulation: $a = 1.16 \times 10^{-7}$
$b = 1.043$

The post-regulation market equilibrium, which is the point where the supply function with regulation and the original demand function intersect, is determined by simultaneously solving the two functions. At this new market equilibrium, the industry will produce 98,960,000 units at a price of $25.30 per unit.

The above market equilibrium analysis indicates that industry production would decrease. The economic impact section of this case study estimates that some of the decrease in production would eventually come from plant closures. The extra-small category plants, because they face the highest incremental costs, become, then, marginal producers and subject to closure. Consequently, based on the analysis of economic impacts, an estimated four of the extra-small plants will close, and the remaining decrease in production will come from the remaining plants in the industry.

Summing the plant compliance costs for the reduced number of plants determines the private sector real resource cost for the industry. These are shown in Table 39. The costs are reported on a cash flow basis; therefore, investment costs are reported in the year the resources are committed, i.e., starting in the first year of the investment. Full compliance is achieved by Year 3, and for each of the two years prior to full compliance, one-third of the firms will comply.

2. Deadweight Welfare Loss

A given regulation may result in society foregoing the consumption of some measure of the goods and services affected by that regulation. This effect (shown in the previous subsection as the decrease in industry output resulting from an incremental price increase) is defined as the deadweight welfare loss and represents the net reduction in consumers' and producers' surpluses which are not accounted for in the private sector real resource costs. 20/ Conceptually, this loss is a measure of consumer willingness-to-pay for the lost output less producer pre-regulation costs. Analytically, this loss is measured by the area between the demand function and the industry's pre-regulation supply curve over the range of output lost due to regulation. For the present case study, the area representing the deadweight welfare loss is shown graphically in Figure 6.

Calculating the deadweight welfare loss resulting from the water pollution control regulation for Industry Q is rather complex since the supply and demand functions are non-linear. However, if it is assumed (1) that the functions are approximately linear around the area of adjustment and (2) that the area representing the deadweight welfare loss is roughly equal to one-half of the area. bounded by the. pre-regulation price, the pre-regulation price plus compliance costs, and the pre-and post-regulation outputs, the loss in precision will be minimal and the area can be approximated with the following equation:

$$DWL_j = \frac{(P_{j-1} - P_j) \times (Q_{j-1} - Q_j)}{2} \qquad (32)$$

20/ The total loss in consumers' and producers' surpluses due to regulation is the sum of the private sector's real resource cost and the deadweight welfare loss.

Table 39. Private sector real resource costs of the proposed water pollution control regulation for Industry Q by model plant and year 1/

	Year	Extra-small	Small	Medium	Large	Total
		($1,000)				
1	1982	2,338	11,017	45,045	22,084	80,484
2	1983	2,936	13,633	52,573	27,167	96,309
3	1984	2,755	14,676	62,551	32,251	112,233
4	1985	1,595	7,476	30,701	15,251	55,023
5	1986	1,595	7,476	30,701	15,251	55,023
6	1987	1,595	7,476	30,701	15,251	55,023
7	1988	1,595	7,476	30,701	15,251	55,023
8	1989	1,595	7,476	30,701	15,251	55,023
9	1990	1,595	7,476	30,701	15,251	55,023
10	1991	1,653	7,756	31,844	15,818	57,071
11	1992	1,711	8,036	32,907	16,384	59,038
12	1993	1,750	8,276	33,968	16,951	60,945
13	1994	1,750	8,276	33,968	16,951	60,945
14	1995	1,750	8,276	33,968	16,951	60,945
15	1996	1,750	8,276	33,968	16,951	60,945
16	1997	1,750	8,276	33,968	16,951	60,945
17	1998	1,750	8,276	33,968	16,951	60,945
18	1999	1,750	8,276	33,968	16,951	60,945
19	2000	1,750	8,276	33,968	16,951	60,945
20	2001	1,750	8,276	33,968	16,951	60,945

1/ Costs are in constant 1982 dollars.

where

DWL_j = deadweight welfare loss in year j

P = equilibrium price,

Q = equilibrium quantity, and

j = year (1, 2, 3, . . . 20)

The annual deadweight welfare loss--equal to $144,000--is calculated by multiplying the incremental price increase, $.30, by the reduction in output, 960,000 units, and dividing by two.

Estimates of the deadweight welfare losses resulting from the water pollution control regulation for years one to twenty are presented in Table 40. Losses in Years 1 and 2 are based on the assumption that one-third of the firms come into compliance in each year. Therefore, the loss in Year 3 represents the annual deadweight welfare loss resulting from 100 percent compliance.

3. Government Regulatory Costs

Regulatory impact analyses have traditionally estimated (though not formally employed) the costs incurred by government to implement and enforce regulations. These costs, because they are a use of resources directly involved in regulatory actions, should be considered a social cost to be included in regulatory impact analyses.

The principal government costs of regulations are those related to the following compliance activities: (1) permitting, (2) monitoring and reporting, (3) enforcement, and (4) litigation. The procedures for estimating these costs are not well defined in published literature; however, various government offices have estimated these costs while developing their regulatory budgets.

Accurately estimating government costs would require allocating the regulatory responsibilities and their costs among federal, state and local government levels. The required resources at each of these levels depend upon the specific regulatory action considered and the projected roles of each level of government.

The hypothetical government costs utilized for the 20-year time horizon of the present study are shown in Table 41. Since specific EPA procedures for estimating such costs are often unavailable, Agency budget planners may well substitute "best judgment" estimates.

Some of the measures that should be considered when estimating each of the principal types of costs are the following:

Table 40. Deadweight welfare loss of the proposed water pollution control regulation for Industry Q by year 1/

Year		Total loss
		($1,000)
1	1982	48
2	1983	96
3	1984	144
4	1985	144
5	1986	144
6	1987	144
7	1988	144
8	1989	144
9	1990	144
10	1991	144
11	1992	144
12	1993	144
13	1994	144
14	1995	144
15	1996	144
16	1997	144
17	1998	144
18	1999	144
19	2000	144
20	2001	144

1/ Costs are in constant 1982 dollars.

Table 41. Government regulatory cost of the proposed water pollution control regulation for Industry Q by year

Year		Total cost 1/
		($1,000)
1	1982	400.0
2	1983	550.0
3	1984	700.0
4	1985	502.0
5	1986	502.0
6	1987	502.0
7	1988	442.0
8	1989	432.0
9	1990	324.0
10	1991	314.0
11	1992	404.0
12	1993	329.0
13	1994	319.0
14	1995	211.0
15	1996	201.0
16	1997	291.0
17	1998	256.0
18	1999	246.0
19	2000	138.0
20	2001	102.0

1/ Costs are in constant 1982 dollars.

Type of Cost	Factors Affecting Cost
• Permitting	• Staff time (administrative, technical and clerical) • Computer time • Number of permits processed
• Monitoring and reporting	• Number of sites • Type of monitoring • Reporting burden and processing time
• Enforcement	• Staff time • Number of sites • Degree of complexity of regulation • Level of enforcement
• Litigation	• Case load (projected) • Level of enforcement

Each type of cost should be estimated as a function of variables that are related directly to the projected growth in emissions (effluents) and compliance assumptions.

4. Adjustment Costs

One of the possible consequences of a regulatory action is that regulatory induced reductions in output may displace resources through such effects as plant closures and job losses. Although, theoretically, these resources will be reemployed in the long run and society will incur only temporary costs, realistically speaking, market imperfections (i.e., variations from the theoretical assumptions of perfect competition) may prevent reemployment of some resources even in the long run. Therefore, adjustment costs should include: (1) the value of the resources temporarily unemployed, (2) the costs of relocating those displaced resources, (3) the administrative costs for transfer payment programs, (4) the welfare loss or gain resulting from resource redistribution, and (5) the value of resources permanently unemployed.

Generally, estimates of such costs are based upon the types of distributional impacts described in the economic impact section of this report; however, it is not always known to what extent displaced resources will be unemployed or underemployed in the long run. When such quantifiable data are unavailable, such costs should be discussed qualitatively.

The adjustment costs in this case study are assumed quantifiable and are a result of the displacement of capital, raw materials and employees. The value of capital investment (plant and equipment) displaced as a result of regulation is measured as the cash flows the firms would have received had no regulations been invoked. If the capital is reemployed, its resultant cash flows are subtracted from and the relocation costs added to the baseline cash flows. If the capital is permanently unemployed, the scrap value of the plant is subtracted from the baseline cash flows. The loss in the value of the resources represented as expenses (i.e., raw materials, wages, etc.) are measured as the reduction in cash flows that, would have accrued to the sources providing the resources in the same manner as displaced capital; however, there is no scrap value for employees. In addition, the government costs to administer unemployment assistance programs are a part of adjustment costs. 21/

The adjustment costs in each year are estimated as the value of lost Productivity from each displaced resource. The resources displaced each year by the regulation are defined in the economic impact section of this case study. Estimating the variables from which the values of the displaced resources can be calculated requires a high level of detail and several assumptions. To simplify this analysis, the present analysis shows only the procedures followed in estimating the adjustment costs of displaced employees. Procedures followed to estimate the adjustment costs for displaced capital, raw material, and other resources are similar.

The adjustment costs associated with displaced employee costs can be reflected by the following equations:

$$TACE_i = FE_i + RL_i + GA_i \tag{33}$$

$$FE_i = [U_i - R_i \cdot B_i] \left[\sum_{n=16}^{65} A(n) \cdot Y(n) \cdot (1+v)^i \cdot P_n (n+i) \right]$$

$$RL_i = NR_i \cdot LC_i$$

$$GA_i = [U_i - R_i] [W_i]$$

where:

$TACE_i$ = total adjustment costs of displaced employees

FE_i = foregone earnings of displaced employees in period i

RL_i = relocation costs of displaced employees rehired in period i

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21/ The maximum value of the capital and expense components of this measure can be seen in Figure 6 as the area bounded by the change in output, the baseline supply curve, and the x-axis. This area represents the value of these resources in their current use and the total adjustment costs for all temporary and permanent unemployment costs (act of government and relocation costs).

GA_i = government administrative costs of unemployment programs in period i

i = period; 1, 2, 3.....20.

U_i = number of displaced employees

R_i = number of displaced employees reemployed in period i

B_i = the productivity level of the best alternative employment

n = age; 16, 17, 18. . . . .65.

A(n) = proportion of employees of age n

Y(n) = mean annual earnings of employees of age n

$P_n(n+i)$ = probability of a person in the general population of age n surviving to a subsequent age n+i.

v = the average annual rate of growth in the labor productivity

NR_i = number of displaced employees rehired in period i

LC_i = relocation costs in period i

W_i = government administrative costs of unemployment programs per recipient in period i

The variable FE_i defines the foregone earnings in period i of all displaced employees. Foregone earnings are defined as the future earnings of employees if they had remained in their original jobs minus the future earnings of employees in their next best alternate job. U_i defines the number of displaced employees and $R_i \cdot B_i$ defines the number of displaced employees finding reemployment in period i and their relative level of productivity in their new job. Future earnings of one employee in a given year are a function of the relative age distribution of all employees A(n); the average income at each age, Y(n); and the probability that the employee will live to that year, $P_n(n+i)$. The administrative costs of welfare programs, W_i, are a function of the employment level. The relocation costs are a function of the number and costs of employees relocated in each period.

Some of the exogenous variables were estimated in this analysis and others were derived from other studies. The variables A(n) and $P_n(n+i)$ are similar to those in Equation 27 of the benefits section of this case study.

The values of these variables were derived from Hartunian, _et al._ (1981). Other variables were derived from the present study's costs and economic impact analysis.

The estimated employment adjustment costs in each year are shown in Table 42, along with the capital, other, and total adjustment costs.

E. Economic Impacts

This section discusses the principal distributional impacts, i.e., equity vs. efficiency impacts, of the proposed water pollution control regulation. This economic analysis includes the following measures of economic effects: financial, price, production, employment, industry profitability, and community effects. Additionally,. when applicable, the Agency's guidelines include concerns such as the balance of trade, energy use, productivity and intergenerational effects that should also be assessed.

Rather than estimating the compliance behavior of all plants, individually and collectively, this analysis is based upon a representative or model plant approach where four sizes of plants--extra-small, small, medium, large--are used to depict the financial and economic profiles of the various plants within the industry. A single, major production process is employed by all four sizes of plants. The model plant analysis estimates the applicable financial impacts of the water pollution control regulation by examining plant revenue and cost measures both before and following regulatory compliance. The resulting microeconomic effects are extended where feasible to estimate industry-wide behavior, including those related to price and production effects as described in Section D.

1. Financial Effects

Four key financial indicators reflecting the economic viability of firms both with and without pollution controls are the following:

- After-tax return on sales,
- After-tax return on total assets,
- Annual cash flow, and
- Net present value.

Analysts, using model plant financial profiles and appropriate assumptions for inflation, depreciation, and reinvestment, can estimate these measures for any designated period of analysis, e.g., 20 years. Such measures should be obtained both for a baseline case (without the regulation) and for each regulatory option so that the financial effects of the proposed regulatory control costs can be assessed. The differences in the financial measures between these two cases will indicate the key financial effects of the regulation.

Table 42. Adjustment costs of the proposed water pollution control regulation for Industry Q by year 1/

	Year	Capital 2/	Employment	Other 3/	Total
		($1,000)			
1	1982	0	0	0	0
2	1983	0	0	0	0
3	1984	200	293	200	693
4	1985	429	82	100	611
5	1986	429	83	0	512
6	1987	429	82	0	511
7	1988	429	81	0	510
8	1989	429	79	0	508
9	1990	429	78	0	507
10	1991	429	77	0	506
11	1992	429	76	0	505
12	1993	429	74	0	503
13	1994	429	73	0	502
14	1995	429	71	0	500
15	1996	429	70	0	499
16	1997	429	68	0	497
17	1998	429	67	0	496
18	1999	429	65	0	494
19	2000	429	64	0	493
20	2001	429	62	0	491

1/ All costs are in constant 1982 dollars.

2/ Includes the cash flow of permanently closed plants, relocation costs of temporarily closed plants and reduction in cash flows of reemployed plants.

3/ Includes raw materials and other expenses.

Although year-to-year variation in the financial measures will occur when annual costs, revenues, reinvestments, and pollution control expenditures are forecast, computing average measures over the period of analysis is often suitable and reflective of the regulation's effects. However, the financial viability of the model plants at the end of the period of analysis should be estimated to reflect the long-term effects of regulation as opposed to the intermediate or short-term effects that may occur because of uneven pollution control costs or reinvestments.

Table 43 illustrates the types of financial data that are frequently developed to form an industry's model plants. Four model plant sizes are shown for this water pollution control case study--all in one industry,. Industry Q. The financial profiles are for the baseline case (in 1982 constant dollars and for the base period, i.e., Year 0). Each of the model plants is economically viable in the indicated base period; for example, the after-tax returns on sales are all positive, ranging from 5.5, to 6.4 percent. Other financial characteristics shown in Table 43 include revenues, costs, gross earnings, pre-tax incomes and cash flows. Each of these model's financial measures is also expressed as a percent of the estimated annual revenue (sales) to facilitate comparing the various financial profiles.

Additional financial profile data and analyses are required to compute the after-tax returns on total assets and the net present values of the model plants' projected operations. The types of financial data preferred are the following:

Total assets	= Fixed assets + current assets
Net working capital	= Current assets - current liabilities
Total invested capital	= Fixed assets + net working capital .
Salvage value	= Net working capital + fixed assets x a salvage factor

Because these types of data change year-by-year for an operating plant, the preferred analytical approach simulates the operation of each model plant (a cash flow analysis) over the study's period of analysis. This. dynamic simulation procedure can be conducted both for the without-regulation (baseline) case and the with-regulation case. Net present value analysis may then be conducted to compare the two cases and assess the financial and economic effects of the regulatory compliance costs.

Table 44 summarizes the investment and the annual operating and maintenance costs of the proposed water pollution controls for each of the four model plants. These data (used to estimate the aggregate or average plant costs presented in Section D) were used here to estimate the financial effects presented below based upon a simulated 20-year discounted cash flow analysis. Furthermore, a price-effects sensitivity analysis is illustrated (see Section E.2.), based upon either plus or minus 10) percent changes in the models' pollution control investment and operating and maintenance costs.

Table 43. Financial profiles for representative plants in hypothetical Industry Q, baseline (Year 0) (1982 constant dollars)

Item	Ex-small		Small		Medium		Large	
	$1,000	%	$1,000	%	$1,000	%	$1,000	%
REVENUE (sales)	4,000	100.0	15,000	100.0	35,000	100.0	50,000	100.0
COST								
Raw Material	1,960	49.0	7,200	48.0	16,610	47.5	23,500	47.0
Labor	800	20.0	2,925	19.5	6,650	19.0	9,400	18.8
Other 1/	640	16.0	2,325	15.5	5,740	16.4	8,600	17.2
TOTAL	3,400	85.0	12,450	83.0	29,000	82.9	41,500	83.0
GROSS EARNINGS	600	15.0	2,550	17.0	6,000	17.1	8,500	17.0
LESS								
Depreciation	110	2.8	380	2.5	875	2.5	1,300	2.6
Interest	120	3.0	425	2.8	1,050	3.0	1,500	3.0
PRE-TAX INCOME	370	9.3	1,745	11.6	4,075	11.6	5,700	11.4
INCOME TAX	151	3.8	783	5.2	1,855	5.3	2,603	5.2
AFTER-TAX INCOME	219	5.5	962	6.4	2,220	6.3	3,097	6.2
CASH FLOW	329	8.2	1,342	8.9	3,095	8.8	4,397	8.8

1/ Other includes insurance, taxes (non-income), selling, administrative and other operating and maintenance costs.

Table 44. Summary of model plant pollution control costs for Industry Q

Model	Number of plants	Pollution control costs 1/	
		Investment	O&M
		($1,000)	
Ex-small	12	580	200
Small	20	1,200	375
Medium	40	2,450	770
Large	15	3,400	1,020

1/ 1982 constant dollars.

a. Return on sales

The model plants' projected 20-year averages of returns on sales (ROS) with and without the proposed pollution controls are shown in Table 45. For example, the extra-small model plant is projected to have an after-tax ROS of 3.6 percent with pollution controls compared to its 6.6 percent without controls. Table 45 also indicates the results for the other three model plants.

Since these ROS effects assume no price increases, all model plants will show decreasing ROS results with pollution controls. Following prospective industry-wide market adjustments, new equilibrium prices will partially or fully offset these ROS effects (see Section D). However, these ROS effects should be considered as worst-case estimates for each of the model plants. (A separate analysis--with a projected price pass through of 1.2 percent--shows that equilibrium ROS reductions are about .6 percent less following this price increase. See Table 45.)

b. Return on total assets

With the increase in total assets that accompanies the addition of pollution controls but no changes in revenues, the model plants' returns on total assets (ROTA) will decrease from their baseline levels. These results are also illustrated in Table 45. For example, Industry Q's Ex-small model plant has an estimated 10.2 percent ROTA with the proposed regulation compared to a 19.3 percent in the baseline case. These estimates are 20-year averages because the ROTA varies throughout the period of analysis.' Such averages reflect the general, long-term financial effects of the proposed regulation.

c. Annual cash flows

The model plants' annual cash flows (after-tax income plus depreciation) were all positive throughout the 20-year period of analysis both with and without the proposed regulation. However, as illustrated in Table 45, the 20th year annual cash flows are lower for the with-pollution control case. For example, the extra-small model plant is forecast to have a cash flow of $862,000 in Year 20 with the proposed regulation compared to its $1,268,000 without the regulation. Similar estimates for each of the model plants are included in the table.

d. Net present value

The net present values (NPV) shown in Table 45 for each of the model plants are the sum of the present values of the annual cash flows over the period of analysis plus the present value of the salvage value of the plant in the 20th year. The discount rate is equal to the estimated firm's cost of capital. Consequently, the NPV indicates the plant's return to equity holders in excess of (or below) the firm's cost of capital.

NPV's may be calculated for each year in the period of analysis, although the 20th year NPV indicates whether the plant will maintain long-run

Table 45. Selected model plant financial effects of the proposed pollution controls compared to baseline conditions for Industry Q, 20-year discounted cash flow analysis

Financial effect	Model Plant Ex-small	Small	Medium	Large
Return on sales (%) 1/				
• Baseline	6.6	7.6	7.6	7.5
• With controls	3.6	6.1	6.3	6.2
Return on total assets (%) 1/				
• Baseline	19.3	22:5	22.5	22.8
• With controls	10.2	17.4	18.1	18.5
Annual cash flow ($000) 2/				
• Baseline	1,268	5,334	12,490	17,680
• With controls	862	4,570	10,923	15,599
Net present value ($000) 3/				
• Baseline	1,124	5,886	14,019	18,548
• With controls	-228	3,334	8,781	11,586

1/ Average annual values over the 20-year period of analysis. With a 1.2 % price increase (market adjustment), the ROS with pollution controls are 4.2%, 6.7%, 6.8% and 6.8% for the extra small, small, medium and large model plants, respectively. Hence, the ROS reductions are expected to be partially offset following market equilibrium adustments. The ROS differences with and without the 1.2% adjustment are +.6%, +.6%, +.5% and +.6% for the extra small, small, medium and large plants, respectively.

2/ Annual values in the 20th year (long-term effect).

3/ Discounted at the estimated after-tax cost of capital rate equal to 11.0 percent.

Note: Results displayed represent a "worst case" assumption (that no costs are passed through to prices); moreover, year-by-year results are not displayed.

economic viability. The positive NPV's in Table 45, except for the extra-small plant with pollution controls, suggest that the small, medium and large model plants will remain economically viable with pollution controls even though the NPV's are substantially lower with the proposed regulation. In the extra-small plant case, the negative NPV with pollution controls suggests that such plants will be only marginally viable, earning below the average cost of capital rate. Unless price increases follow, plant closures might be expected (as discussed below).

2. Price Effects

Although additional industry-wide behavior and often macroeconomic analyses are required to forecast actual market price effects (see Section D), an initial indicator of the regulation's potential price effect is the required price increase by a firm to maintain its profitability at the pre-control level. Based upon discounted cash flow procedures to estimate present values of pollution control costs (i.e., investment plus operating costs less tax savings), the analysis employed the following formula to estimate each model plant's required price increase (RPI):

$$RPI = \frac{(PVC)(100)}{(1-t)(PVR)} \qquad (34)$$

where

PVC = present value of pollution control costs

PVR = present value of gross revenue beginning in year that pollution controls are imposed

t = average tax rate

As indicated, each model plant will probably have a different required price increase to maintain its baseline profitability level. The following estimated required price increases are those for each of the study's model plants. As shown, also, ranges in the required price increases illustrate the sensitivity of this financial measure to alternate pollution control costs, i.e., ±10 percent from the original estimates.

Industry Q	Required price increase with regulation (%)*		
Model Plant	-10% PCC	Target PCC	+10% PCC
Ex-small	3.6	4.0	4.4
Small	1.9	2.1	2.3
Medium	1.7	1.9	2.0
Large	1.6	1.8	1.9

* Pollution control costs (investment and operating and maintenance) were varied from their initial levels (target PCC) by plus and minus 10 percent.

These required price increases indicate that the smaller model plants will be impacted more adversely by the proposed regulation than the larger plants. In a competitive market, each firm may well be unable to adequately adjust prices independently, and as was predicted in the previous Section--D. Social Costs--the adjusted market equilibrium price with pollution controls will increase by 1.2 percent.

Such a price increase will at least partially offset the financial effects of the proposed regulation for all firms, although for the extra-small model plants, in particular, this price increase will not result in the maintenance of the plant's former profitability level. The net price effect for each model plant is the difference between the former required price increase required and the estimated industry-level price increase.

3. Production Effects

Because the production effects of a regulation are dynamic, total industry production should be estimated annually for the period of analysis both with and without the proposed regulation. The projected reduction in the industry production of .96 percent associated with the expected market price increase as forecast in Section D is an indicator of the production effect that will occur annually throughout the period of analysis. However, further analyses of industry trends and growth potentials both with and without the proposed regulation are desirable for the analysis to be fully responsive to studying the effects of regulatory compliance.

In a growing industry, short-term production curtailments may be relatively quickly reversed through trend increases in aggregate demand and supply. This condition may effectively reduce any detrimental impacts of regulation over time; however, despite industry-wide growth over time, plant closures may occur (above the baseline rate) in marginal plants. Often compensatory increases in production from existing or new large plants will occur; in such situations, aggregate industry data will not adequately reflect the equity-related effects of production changes.

The present hypothetical case study indicates that four of the extra-small model plants will close following the imposition of the proposed regulation--an indication that is based upon presumed additional financial data on Industry Q's plants and upon variations in their financial characteristics. Given the average production per extra-small model plant, the total production effect from plant closures is equal to 960,000 units. This amount represents .96 percent of the estimated aggregate production decrease following the new market equilibrium production and price levels. The balance of the estimated industry-wide production decrease is expected to be distributed among the remaining or new firms, although much additional plant data would be required to forecast the distribution of these effects.

The above general statement of effects summarizes the production effects analysis. The analytical procedure used to arrive at the above conclusions is explained below:

for this water pollution control case study, the affected Industry Q should experience a market equilibrium adjustment following the upward shift in the industry's supply function from its pre-regulation level with a new higher equilibrium price and a lower equilibrium quantity (for a given time period). As previously described in Section D, the measurement of these effects requires that both supply and demand elasticities (or functions) be known. A listing of these estimates for this case study is the following:

• Supply price elasticity	+.96 to +.959
• Demand price elasticity	-.43
• Price effect	41.2%
• Quantity effect	-0.96%

The aggregate production effect will be theoretically distributed among all plants in the industry, that is, each plant's new marginal cost of production will equal the adjusted equilibrium price. Because the smaller plants' marginal costs are expected to shift upward relatively more than those of the larger plants, the small plants will generally incur relatively larger production cutbacks than will the larger plants.

Plant closures are expected if one or more of the model plants are no longer viable with pollution controls--including the adjusted market equilibrium price effects. This study estimated plant closures by re-estimating the net present values (NPV) of each model plant using the adjusted market prices and the average production effect. If the NPV is negative or only marginally positive, some fraction of the representative model plants will likely close. (Presumably actual plants represented by a given model will have profitability levels distributed normally around the estimated profitability level of the model. Hence, for example, if the extra-small model plant has a re-estimated NPV near zero, some actual plants would have negative NPV's and would be predicted to close. Unless actual data for each plant are known, such a qualitative estimate of probable plant closures is required.)

As summarized in Section E.1.d. of this study, the NPV of the extra-small model plant was negative (-5228,000) with pollution controls and with no price increase. With the new equilibrium price increase of 1.2 percent, the NPV of the extra-small model plant was estimated at approximately zero. Because some actual plants are expected to have NPV's both higher and lower than this model plant estimate, it is probable that some plants with remaining negative NPV's will close. Additional industry- and plant-specific data are needed to more explicitly estimate which plants in the industry will close. For this case study and as indicated previously, four (or one-third) of the extra-small plants are projected to close rather than comply with the proposed regulation. The baseline quantity of production lost through that closure is 640,000 units, assuming that each plant produced at the average model plant level.

The consequences of these plant closures are discussed further below. Other plants in the industry will respond according to additional adjustments in the industry-wide supply function. Perhaps more critically, job losses will occur and measurable community effects may follow.

4. Employment Effects

As explained in the air pollution control case study, both favorable and unfavorable employment effects generally occur when pollution control regulations are imposed. Short-term construction employment will increase for the installing of the pollution controls. In this case study, a total construction employment of 550 work years is forecast for Industry Q. In addition, long-term.personnel are expected to be employed to operate and maintain the pollution control equipment. A total of 263 employees are projected as required in Industry Q (1 employee in each viable extra-small plant, three employees each in the small and medium plants, and five employees in each large plant). Some additional and favorable secondary employment effects may occur in pollution control supplying industries (equipment and supplies), although this case study presumes that such secondary effects will be negligible, i.e., equipment and supplies can be supplied by existing suppliers without the need for expansions by these industries.

Given the projected closure of four extra-small plants, some employment decreases will occur within the industry. A total of 160 jobs (40 per extra-small model plant) are forecast to be lost because of these plant closures. Additionally, were there to be any reduced industry production following the market adjustments, the potential would exist for lay-offs within existing plants corresponding to the relative decrease in each plant's output. However, this effect is estimated as negligible for the case study. Secondary employment effects are also expected to be negligible because the change in industry-wide production is relatively small. (Secondary effects in those communities where plants are projected to close will probably be consequential. These effects are described further in the next section.)

Net employment effects from the pollution control regulation are positive.

5. Community Effects

Where it appears necessary to assess the community effects for an actual regulatory impact analysis on an other than superficial basis, knowledge of the communities in which affected plants are located is required, particularly a socioeconomic documentation of those communities where plant closings are projected. The model plant analysis of the present study could not be utilized to determine this type of effect. This case study's extra-small plant closures, for instance, may have from minor to major community effects depending upon their location either in a large, urban area or in a small, rural setting where the affected plant is a major employer in the community. In the former case, dismissed employees may readily find alternative employment with limited transition costs. In the latter case, the opportunities for re-employment in similar jobs may be quite limited: some employees may have to commute outside the local area or leave the community, and some may not be re-employed for age, health, or other reasons.

This report assumes that a separate community effects analysis has been performed and that those communities which will be affected by plant closings are specifically known. A partial summary of this assumed analysis is the following:

- Three communities are affected by the four plant closings.

- One community is a large, urban community in Region 1. Within two months following the plant closing, 90 percent of the forty employees are expected to be comparably re-employed in the community. About 5 percent of the employees are expected to retire early or be permanently unemployed (with an average 10 years of lost earnings per employee). The remaining 5 percent are not expected to be re-employed for six months and then to find jobs at a wage level below (75%) their former earnings.

- One community is a medium-sized community (Community A in Region 2) within commuting distance of other communities that have jobs requiring similar skills. Within two months, 50 percent of the employees are expected to be re-employed in the community, 45 percent are expected to commute to nearby communities, and 5 percent will retire early or be permanently unemployed.

- One community is a relatively small community (Community B in Region 2) with two plant closings. The commuting time to other communities is about one hour. No other plants in the community require similar employee skills for about 50 percent of the workers. Approximately 40 percent of the combined plants' employees are expected to be re-employed in the community within four months. About 30 percent will be re-employed outside the community within 4 months and commute. About 5 percent will retire early or be permanently unemployed. Finally, about 25 percent of the former employees will move to other communities to find comparable employment opportunities within four months.

- Estimates of the annual financial and social costs of these community effects were included in the Social Costs section above (Section 0.4).

- Secondary employment and community effects are consequential in Community B. A local raw material supplier to the affected plants will close, though its five employees will probably be transferred by the supplier's parent company. Also, a total of twenty employees in service-related businesses are projected to be laid-off because of reduced local demands for such services as cleaning, transportation, retail sales, and food services. Within one year, 90 percent of these employees are expected to be re-employed, although 30 percent will also leave the community.

6. Trade Effects

The international trade effects of the proposed regulation are assumed to be negligible for this case study. As described in the air pollution. control case study, a comprehensive analysis of market supplies by source is critical if a significant share of the market is imported. Also, if foreign demands are substantial, the effects of pollution controls will include a balance of trade effect. In general, a supplemental market supply-demand analysis by source is required to estimate the probable balance of trade effects.

7. Other Effects

The proposed water pollution controls for Industry Q are forecast to have no effect on the productivity of the model plants. The abatement technology is an end-of-pipe treatment alternative that does not affect the manufacturing process.

The proposed regulation will increase the energy requirements of the model plants by an average of 5 percent; however, this increase when aggregated for the industry, represents less than 0.1 percent of the total industrial energy use in the study regions.

The intergenerational effects of the proposed regulation stem from benefits (reduced damages) of pollution control as described in Section C. Without the proposed regulation, certain carcinogenic health damages and ecosystem disruptions caused by the carcinogenic Pollutant Z will continue and. increase over time. These prospective effects are not considered irreversible, however.

F. Net Benefits Timestreams and Sensitivity Analysis

1. Net Social Benefits

Net social benefits were estimated for each period (year) of the analysis as follows:

$$NSB_t = TSB_t - TSC_t \qquad (35)$$

where

NSB_t = Net Social Benefits

TSB_t = Total Social Benefits

TSC_t = Total Social Costs

t = year t

The total social benefits of the proposed regulation are as determined in Section C of this case study; the total social costs are as determined in Section D. A summary of these estimates of benefits and costs and the derived net social benefits are shown in Table 49. The NSB's are negative in the early years (reflecting high initial investment costs) and positive in the latter years of the period of analysis.

The NSB's presented in Table 46 are undiscounted values in 1982 constant dollars. As is customary, the NSB's may each be converted into a present value by using a specified "social discount rate" and then summed for all twenty years to obtain a single net present value of the stream of discounted NSB's. For example, using a discount rate of 10 percent as specified by OMB, the present value of the Net Social Benefits for the proposed water pollution control regulation is $88.6 million.

Because this NSB present value is positive, the proposed regulation's benefits exceed its costs (including society's time-value of benefits and costs). Provided that similar results are obtained for various regulatory alternatives, the alternative that will provide the greatest NSB present value can be determined.

The NSB analysis summarizes all of the quantifiable and monetizable benefits and costs of the proposed regulation. However, an additional qualitative assessment should be conducted to assess benefits or costs that are not "valued" in the preceding analyses. For example, this study's human health benefits analysis (Section C) includes an estimated 13 deaths avoided because of the proposed regulation. This is an additional benefit of the proposed regulation. (Were quantifiable costs to exceed quantifiable benefits, the excess cost per death avoided would be calculated and presented.) Other qualitative effects of the proposed regulation were summarized in Section A.

Table 46. Undiscounted total social benefits, total social costs and net social benefits for the proposed Industry Q water pollution control regulation by year

	Year	Total social benefits 1/ Estimate	Total social benefits 1/ Range	Total social costs 2/ Estimate	Total social costs 2/ Range	Net social benefits 3/ Estimate	Net social benefits 3/ Range
		------	------	------	millions of dollars	------	------
1	1982	26.2	18.5- 32.1	80.9	73.3- 88.6	(54.7) 4/	(54.8)-(56.5)
2	1983	51.5	37.1- 65.3	96.9	87.8-106.1	(45.4)	(50.7)-(40.8)
3	1984	77.7	56.9- 98.8	113.8	102.9-124.6	(36.1)	(46.0)-(25.8)
4	1985	78.6	57.4- 99.9	56.3	51.0- 61.6	22.3	6.4 - 38.3
5	1986	79.4	58.1-101.0	56.2	50.9- 60.5	23:2	7:2 - 40:5
6	1987	81.7	59.6-103.7	56.2	50.9- 60.5	25.5	3.7 - 43.2
7	1988	92.3	67.7-117.2	56.1	50.8- 61.4	36.2	16.9 - 55.8
8	1989	93.5	68.5-118.4	56.1	50.8- 61.4	37.4	17.7 - 57.0
9	1990	94.4	69.3-114.6	56.0	50.7- 61.3	38.4	13.6 - 53.3
10	1991	95.4	70.2-120.9	58.0	52.5- 63.5	39.4	17.7 - 57.4
11	1992	96.4	70.8-122.3	60.1	54.2- 65.8	36.1	16.6 - 56.5
12	1993	97.7	71.5-123.6	61.9	56.0- 67.8	35.8	15.5 - 55.8
13	1994	98.6	72.4-124.8	61.9	56.0- 67.8	36.7	16.4 - 57.0
14	1995	99.8	73.4-126.2	61.8	55.9- 67.7	38.0	17.5 - 58.5
15	1996	100.6	74.0-127.8	61.8	55.9- 67.7	38.8	18.1 - 60.1
16	1997	101.9	74.9-128.8	61.9	56.0- 67.7	40.0	18.9 - 61.1
17	1998	103 .o	75.7-130.3	61.8	56.0- 67.7	41.2	19.7 - 62.6
18	1999	104.0	76.5-131.5	61.8	56.0- 67.7	42.4	20.5 - 63.8
19	2000	105.3	77.2-133.0	61.7	55.9- 67.6	43.6	21.3 - 65.4
20	2001	106.5	78.3-134.8	61.7	55.8- 67.6	44.8	22.5 - 67.2

1/ Expressed in 1982 dollars (using a forecast of the GNP Implicit Price Deflator).
2/ In 1982 dollars.
3/ Total social benefits minus total social costs.
4/ Numbers in parenthesis are negative.

2. Sensitivity Analysis

The present values of the benefits and costs timestreams may vary markedly based upon differing social discount rates. A summary of the present values of the total social benefits, total social costs, and the net social benefits for the proposed water pollution control regulation is the following:

	Present Value*			
	6%	8%	10%	12%
	-------------millions of dollars-----------			
Social Benefits	958.7	802.2	679.8	583.1
Social Costs	775.6	672.8	591.2	525.5
Net Social Benefits	183.1	129.4	88.6	57.5

* The benefits and costs timestreams were expressed in 1982 constant dollars before discounting.

This sensitivity analysis illustrates that the NSB present value decreases as the discount rate increases, and it would change from being positive to negative at about a 17 percent social discount rate. At the OMB proposed rate of 10 percent, the present value of the NSB timestream is $88.6 million. A second type of sensitivity analysis indicates the effects of variations in either the total social benefits or the total social costs. Benefits ranges were previously estimated in Section C, and costs ranges were estimated in Section D. Such ranges reflect the uncertainties in available data and in implementable analytic procedures that are present throughout this type of analysis Table 46 includes a summary of the ranges in total social benefits, total social costs, and net social benefits for the proposed water pollution control regulation.

Many combinations of benefits and costs values are potentially applicable. Table 47 summarizes two such sets of benefits and costs conditions:

1. Maintain Total Social Benefits at the primary-estimate level while varying the Total Social costs from their low to high levels. (Discount rate equal to 10 percent.)

2. Maintain Total Social Costs at the primary-estimate level while varying Total Social Benefits from their low to high levels. (Discount rate equal to 10 percent.)

For example, when the high TSC values are assessed in combination with the TSB primary (target) estimates, the present value of the NSB timestream is $32.6 million versus $88.6 million when both the TSC and TSB timestreams are at their target levels. Table 47 illustrates the other defined cases in the two sets.

Table 47. Present values of net social benefits for selected ranges in total social costs and total social benefits for the proposed water pollution control regulation

Sensitivity conditions	Net social benefits present value 1/
	($ million)
Social Benefits-Constant 2/	
Social Costs - High	32.6
Social Costs - Moderate	88.6
Social Costs - Low	104.4
Social costs - Constant 2/	
Social Benefits - High	267.7
Social Benefits - Moderate	88.6
Social Benefits - Low	-96.9

1/ All present values of net social benefits were calculated using a 10 percent discount rate.

2/ Social benefits (and social costs) are held constant at the primary estimate (moderate) level while social costs (social benefits) range from high to low as defined in Table 46.

The cases in Table 47 do not include either the "best" (high benefits and low costs) or the "worst" (low benefits and high costs) cases reflected in the TSC and TSB ranges previously described. The present values of the NSB timestreams (10 percent discount rate) for these two extreme cases are the following:

Case	Present value ($million)	Comment
"Best"	283.5	High benefits; low costs
"Worst"	-152.9	Low benefits; high costs

All other benefit-cost combinations within the ranges estimated will have present values between these extremes using the 10 percent social discount rate.

G. Cost-Effectiveness

A summary description of the purpose and procedures for conducting cost-effectiveness (C/E) analysis is presented in Section II-G of the air pollution control case study. As explained there, C/E analysis may be used to determine those regulatory options that are least-cost (and that form the least-cost envelope curve as was shown in Figure 4) among all alternatives assessed. The preferred regulatory alternative will be in the least-cost set, and further detailed cost-benefit analysis need only be performed for this subset to estimate the socially optimum level of pollution control.

Because only hypothetical data and relationships are being presented in this report, the C/E analysis presented in the air pollution control case study is similarly applicable to the water pollution control case study. The reader is referred to Section II-G for an explanation of C/E analysis procedures.

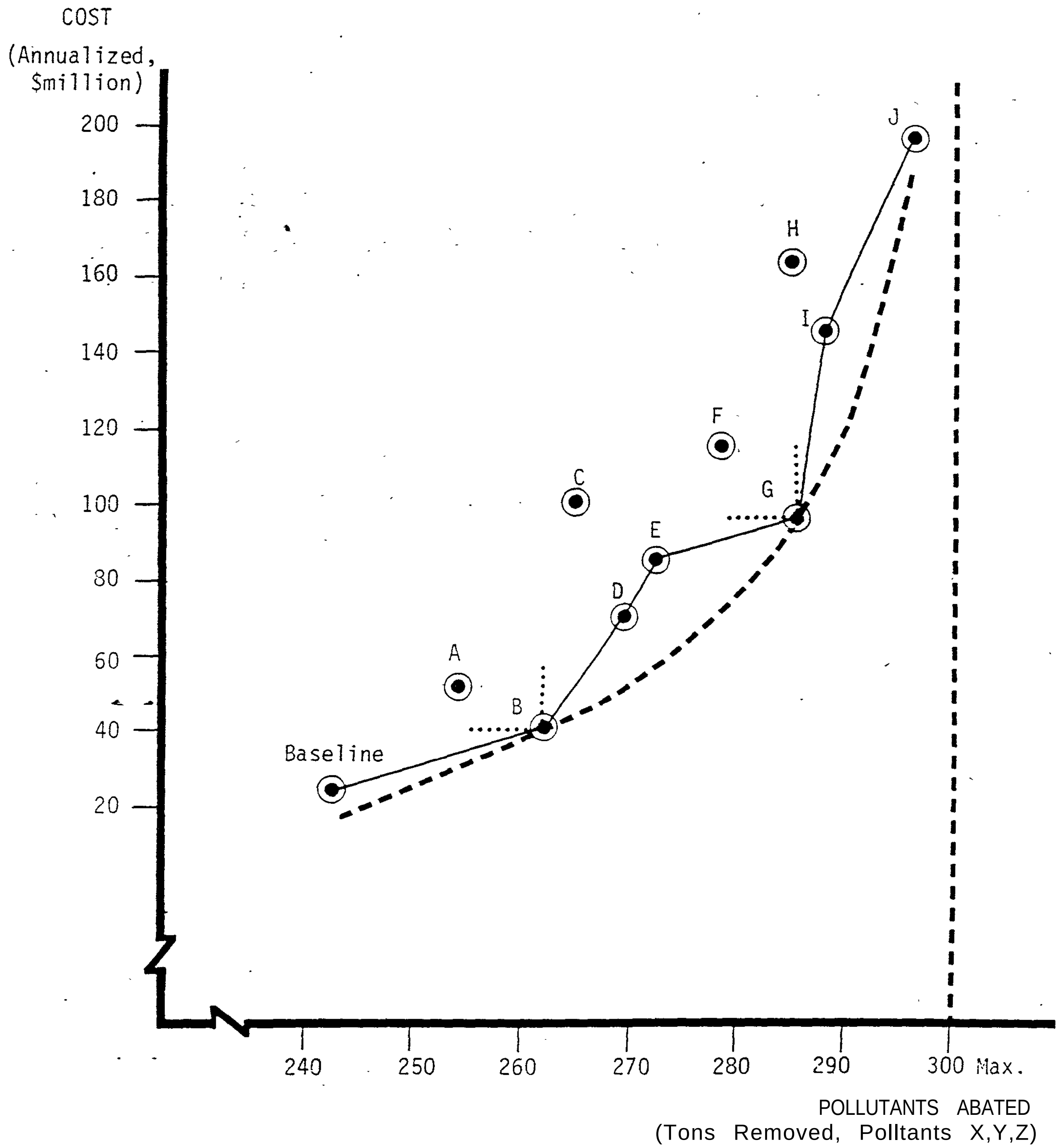
In actual applications of C/E analysis, however, analysts seldom are able to define an initial set of regulatory options which will produce a "smooth" least-cost envelope curve as was previously depicted in Figure 4. Actual C/E analyses will examine various regulatory alternatives in order to determine their comparable values. Figure 7 shows the ten regulatory alternatives, A to J, that were initially defined for this water pollution control case. Estimates of each alternative's annualized costs and effectiveness level (abatement of water Pollutants X, Y and Z) produce the points depicted in Figure 7 and illustrate that six of the ten alternatives are "dominant" and only four alternatives can be said to be "inferior" (i.e., alternatives A, C, F and H). Further, the line segments connecting the adjoining dominant alternatives (the least-cost set) produce an irregular envelope curve. Although a theoretically-defined marginal cost-effectiveness (MCE) curve might be superimposed (see the dotted-line in Figure 7), analysts may not categorically exclude dominant alternatives whose C/E values are not tangent to (or near) the theoretical MCE curve.

Using C/E analysis only, regulatory alternatives A, C, F and H can be shown to be inferior to one or more of the remaining alternatives, e.g., Alternative C is dominated by Alternatives D, E and G in Figure 7. These inferior alternatives need not be assessed further, i.e., receive full benefit-cost analyses.

Provided that a thorough C/E analysis is performed and that benefit cost analyses are made for each least-cost alternative, the choice among the least-cost set of alternatives (B, D, E, G, I, and J) can be made on the basis of each alternative's maximum contribution to net social benefits, i.e., NSB = TSB - TSC.

Presuming that benefit cost analyses were completed (as for the regulatory alternative described in the preceding sections), the following comparison, could be made:

Figure 7. Cost-effectiveness of the proposed water pollution control regulation (Alternative G) compared to other selected alternatives



Alternative	Present Value ($million) TSB	TSC	NSB
G */	679.8	591.2	88.6
B	610.0	549.5	60.5
D	639.2	580.2	59.0
E	646.0	591.0	55.0
I	683.0	657.5	25.5
J	708.8	721.0	-12.2

*/ Alternative G is the proposed regulatory alternative.

These data show that regulatory Alternative G will contribute $88.6 million to NSB and that all other alternatives will contribute less. This is true even though Alternatives I and J are estimated to provide a greater amount of pollutant abatement (effectiveness). Because the regulatory alternatives assessed are limited and discrete, one could not know whether an unspecified alternative with either more or less effectiveness than Alternative G would yield an even greater NSB than would Alternative G.

In summary, C/E analysis is a rigorous analytical technique to reduce effectively the number of alternatives requiring further benefit cost analysis. The fundamental procedures for conducting a C/E analysis were presented in the previous air pollution control case study (Section II-G) and they are not repeated here, The emphasis of the present water pollution control case's C/E analysis was to suggest that, even though C/E analysis is applicable, its use may not produce theoretically "uniform" empirical results. In general, carefully defining the original set of regulatory alternatives is important in obtaining an accurate, representative least-cost subset of alternatives for further cost benefit analysis.

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